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AN INVESTIGATION OF THE CONSTRUCTION OF THE VARIOUS KINDS OF CUPOLAS THAT HAVE BEEN USED FOR THE MELTING OF PIG-IRON.

BY M. A. GOUVY, JR.*

Translated by W. F. Durfee, Engineer.

(*Continued from Vol. cxxvi, page 447.*)

V.

CUPOLAS HAVING SUCTION BLAST.

Long before the steam ejector was invented, natural draft had been tried, but the melting capacity of the cupolas to which it had been applied was very small; there being a

* Étude sur les cubilots pour la fusion de la fonte. Par M. A. Gouvy Fils," published in "Mémoires et compte rendu des travaux de la Société des Ingénieurs Civils." Paris, 1887. pp. 723-766.

considerable loss of heat, because the time required to attain the melting heat of iron was relatively long, and the quantity of air supplied simply by the draft was very limited.

As early as 1855, Kerl speaks of a natural draft cupola at *Zintgraff;* more recently *Heaton* erected at Langley Mills a cupola on the same system, and in 1865 *Canhon* obtained a patent for an analogous construction; all these cupolas have been abandoned for the reasons above given.

Sir R. Mallet, in an article written in 1871,* speaking of the Heaton cupola, makes the following critical remarks, which we regard as very just:

"That this apparatus will melt iron is evident, if sufficient time is allowed to obtain the necessary heat." * * * "This furnace may be well suited to the Heaton process, in which the demand for iron is regular, and in some degree continuous; but it is not good for anything in a foundry."

The employment of a jet of steam to force the draft is subject to only a part of the objections to the foregoing methods; and the *Woodward* cupola, patented in 1865, does not embody all the advantages that we desire.

The Woodward Cupola.—This cupola, *Fig. 22*, was furnished with two rows of tuyeres; the upper row was the smaller and intended for lighting the cupola, being closed during ordinary work, but were opened in case it was desired to obtain the greatest possible product. The suction was produced at the centre of the neck of the cupola, by a jet of steam in a chimney of sheet-iron. The pressure of the steam used varied from forty-five to fifty-five pounds per square inch. The charge was introduced by means of a lateral hopper.

Sir R. Mallet, in the article already cited, speaks very unfavorably of this system, saying:

"There will be required a high pressure boiler, without a steam engine; but a low pressure boiler and a fan, driven by a steam engine, will produce the same results with much greater ease."

This criticism is a little exaggerated, as it is not really

* *Practical Mechanics Journal*, 3d series, vol. 5.

necessary to have a pressure beyond forty-five to fifty-five pounds, and the absence of a steam engine is an important advantage when considered with reference to the first cost of an establishment and its subsequent maintenance; finally, we can regulate the draft at pleasure by modifying the dimensions of the ejector and the admission of steam thereto.

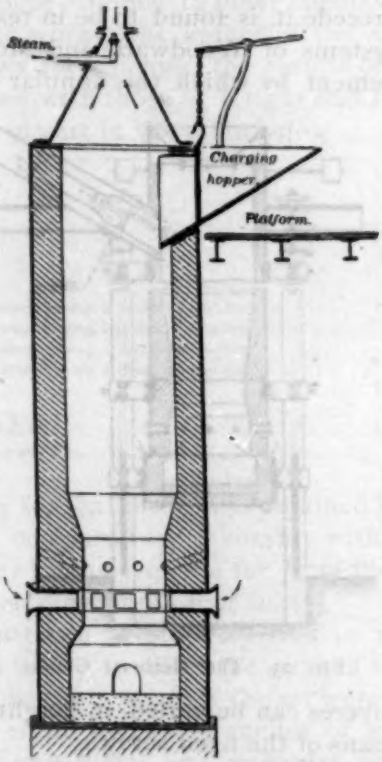


FIG. 22. The Woodward Cupola.

As regards the consumption of fuel, the Woodward system has given variable results, which may properly be attributed to the different dimensions of the tuyeres, which were generally too small, and also to incomplete combustion due to an irregular distribution of oxygen, as has been before said.

The Herbertz Cupola.—In the cupcla, patented by M. Herbertz, of Cologne, at the commencement of this year (1887), (*Fig. 23*), the first of the disadvantages inherent to all the old systems in which high pressure blast, with very contracted tuyeres, was employed, is overcome, since we can augment at pleasure the area of the annular tuyere; but the second still remains. This cupola, when compared with those which precede it, is found to be in reality a combination of the systems of Woodward and McKenzie, with a slight improvement by which the annular aperture which

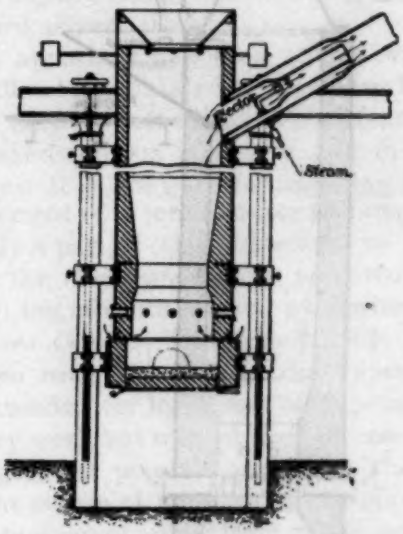


FIG. 23. The Herbertz Cupola.

replaces the tuyeres can be varied in height, by raising the crucible by means of the fixed screws.

The consumption of steam * for creating a draft, amounted to 204 pounds per hour, with an ejector whose diameter was four-tenths of an inch; in case a Root blower (requiring about three horse-power) were employed, the consumption of steam would be in the vicinity of 198 pounds; so there is not much economy in that direction. With

* *Stahl und Eisen*, No. 6, Juni, 1886, p. 399, and *Revue Industrielle*, Mai-Juin, 1886, p. 541.

regard to the consumption of fuel, the trials made in December, 1885, at Cologne, with a coke having three per cent. water and 6·8 per cent. ash, gave five per cent. of coke for melting, and 9·9 per cent altogether (this included the coke for lighting, the small coke recovered at the end the "heat" being deducted).

These results are evidently satisfactory, but do not very much exceed those attained in other cupolas in actual use in well managed works; the author of the article in *Stahl und Eisen*, shows for example the results of the Herbertz cupola, compared with those of Krigar and Ireland, and we now reproduce in part in the table below:

Trials.		Coke in Per Cent. of Iron.	
		For Melting.	Total.
1	Kreigar System having a detached crucible,	8·70	12·40
2	Kreigar System having a detached crucible,	6·32	16·70
3	Kreigar System having a detached crucible,	5·10	8·50
4	Kreigar System having a detached crucible,	6·70	9·10
5	Ireland,	12·00	18·70
6	Ireland,	13·20	14·70
7	Herbertz, first trial,	5·00	9·90
8	Herbertz, second trial,	10·20	12·70

From this we see that the results obtained by the Herbertz cupola do not compare very favorably with the other systems, while they themselves are far from the requirements of theory in their consumption of coke.

This circumstance is probably due to the pressure of blast being too feeble to allow the oxygen to penetrate the pores of the coke, as it would if the air were injected under a pressure of eight to twelve inches of water; the combustion being superficial and irregular, and also to the deviation of the currents of air drawn to the very short chimney by the steam aspirator, and finally to an excess of air as shown by analysis.

The gas from the tops of the cupolas of Krigar and Ireland is composed (in *volumes*) as follows, viz:

12·42 to 16·55 per cent. of CO^2

2·55 to 11·73 per cent. of CO

and 0 per cent. of oxygen; whereas in the Her-

bertz cupola we find, according to the author already cited:*

10·7 to 11·5 per cent. of CO^2

0 to 3·4 per cent. of CO

6·7 to 8·2 per cent. of oxygen, or 7·5 per cent. as an average.

Which means that in every 100 cubic feet of gas which traverses this cupola, there is

$$\frac{100 \times 7{\cdot}5}{21} = 37{\cdot}7$$

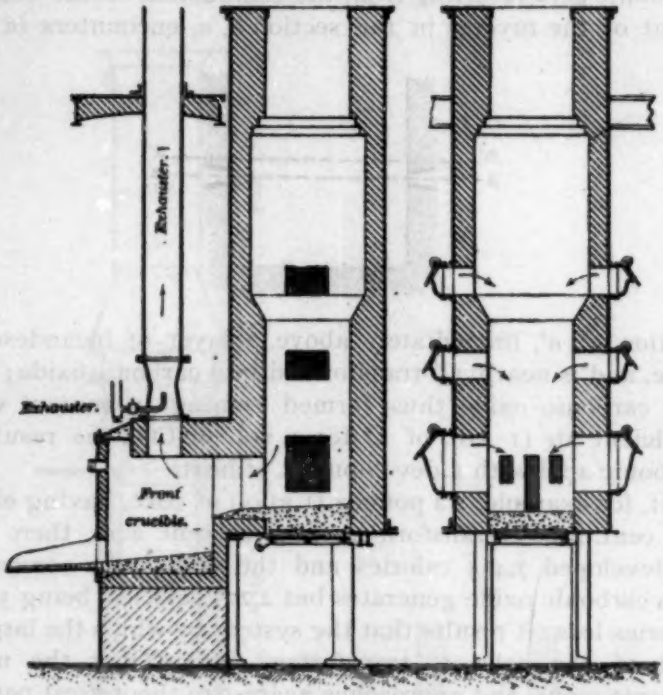
cubic feet of useless air drawn in, which must have carried off a notable quantity of heat, in addition to that lost by the escape of 2·55 to 11·73 per cent. of carbonic oxide not transformed into CO^2.

However, if we recognize the fact that for every 220 pounds of iron charged there is from 504 to 630 cubic feet of air used, we shall be able easily to account for the loss. We must add finally that the production is very small when compared with cupolas of the same diameter using a forced blast.

Krigar's cupola with forced draft.—In 1884, M. Krigar had also obtained a patent for a cupola having a detached crucible; this cupola was blown by a jet of steam placed over the detached crucible, which drew the air through large openings in the sides of the cupola, which were provided with regulating valves for directing the air toward the crucible, into which it was drawn, and from which it was forced by the ejector, which was placed in the small chimney before named (*Figs. 24* and *25*). The zone of fusion is therefore below the entrance of the air. In this system it is true that the gas is available for maintaining the heat of the iron gathered in the detached crucible, although the charge is not heated in advance of its arriving at the zone of fusion, but, on the contrary, it is traversed by the cold blast, and although we know nothing of the results which have been attained in practice, we believe that we are correct in saying that this cupola is far from realizing any economy in fuel; at its best it will not waste as much iron,

* *Stahl und Eisen*, No. 6, Juni, 1866.

and therefore there will be less decarburization, as the metal is not, as in the other systems, under the influence of an



FIGS. 24, 25. The Krigar Cupola with Forced Draught.

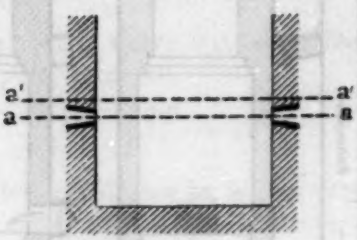
ascending current of air, and an atmosphere more or less oxidizing.

VI.

COMPLETE COMBUSTION OF THE CARBONIC OXIDE.

In all the systems which we have passed in review, the complete transformation of the coke into carbonic acid has received but secondary consideration; whereas this is one of the most important conditions for economical melting, and it does not appear that we have taken sufficient account of the fundamental principles by which carbonic acid, when in contact with carbon heated to a red heat, gives up one-half of its oxygen and passes to the state of carbonic oxide.

In all cupolas having a single row of tuyeres placed from 27·5 to 31·5 inches above the bottom of the crucible, the carbonic acid resulting from the combustion of the coke in front of the tuyeres in the section *a*, *a*, encounters in the

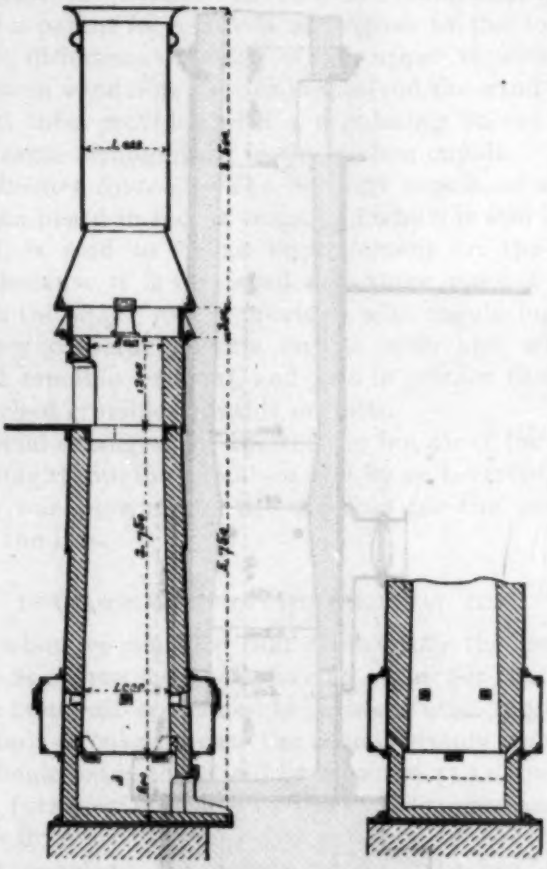


section a^1, a^1, immediately above, a layer of incandescent coke, and is nearly all transformed into carbonic oxide; and the carbonic oxide thus formed coming in contact with sufficient air (1 vol. of O for 1 vol. of CO), the result is carbonic acid with a development of heat.

If, for example, 2·2 pounds (1 kilo.) of coke, having eight per cent. ash, is transformed into carbonic acid, there will be developed 7,434 calories, and the same coke converted into carbonic oxide generates but 2,275 calories, being 5,159 calories less; it results that the system by which the largest part of the coke is transformed into CO^2 is the most advantageous, and approaches nearest to theoretical perfection, without regard to the fact that with the same sized cupola we are able to melt a very much greater quantity of iron per hour.

The Voisin Cupola.—M. Voisin appears to be one of the first to have given attention to this point; in some investigations for determining as exactly as possible the space above and below the axis of the tuyeres, occupied by the zone of fusion, he found that this zone extended at most but six inches in each direction. We are, therefore, easily able, by measuring the temperature at various heights, to ascertain the level at which the most carbonic oxide is formed, and it is at this level that M. Voisin places a second row of tuyeres, with the intention of re-forming carbonic acid and thus create a second zone of fusion.

With the Voisin cupola, illustrated by *Figs. 27* and *28*,* 100 pounds of iron were melted with eight pounds of coke, a result which has been augmented nearly twenty per cent.,



FIGS. 27, 28. The Voisin Cupola. Section through the Lower Tuyeres.

although the coke was of an inferior quality; the system is also very easy of application to existing cupolas.

The Angiers Cupola.—The cupola established at the Ecole des Arts et Metiers, at Angiers,* has an arrangement simi-

* Armengaud: *Publication Industrielle.* Vol. 22, p. 185.

lar (*Fig. 29*) to the Voisin cupola; the vertical section is somewhat different, as it presents a contraction above the upper row of tuyeres, whereas the preceding cupola is simply conical.*

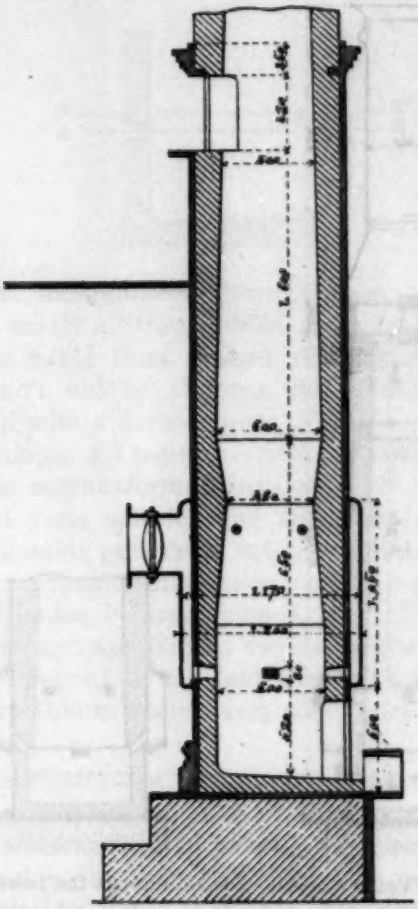


FIG. 29. The Cupola of the School at Angers.

The Angiers cupola has four tuyeres in each row; they are of a circular section 2·16 inches in diameter; the two rows are 25·6 inches apart.

* The profiles used for the Voisin cupola are not of necessity conical, as is indicated by the figures in the table annexed to this paper.

With a pressure of 8·66 inches of water they are able to melt 8,816 pounds of iron per hour, with a consumption of from 8·4 to 9·3 per cent. of an average quality of coke.

The Hamelius Cupola.—In 1880 M. Hamelius, of Paris, obtained a patent for a cupola analogous to the foregoing, with this difference: instead of the upper tuyeres having one common wind-box, they each received the wind through a vertical tube provided with a regulating valve; we also find the same arrangement in the Bichon cupola.

*The Stewart System.**—The Stewart cupola, of which we have often heard in recent years, and which is still in use in England, is said to be an improvement on the Voisin system, because it is furnished with three rows of tuyeres, of which the upper row is provided with regulating valves.

Stewart constructed this cupola with and without a detached crucible in front, and also in certain cases made the detached crucible movable on rails.

A special arrangement allowed the hot air of the crucible to be brought into the wind-box, and by an inverted injector cold air was blown into the crucible for the purpose of refining the iron.

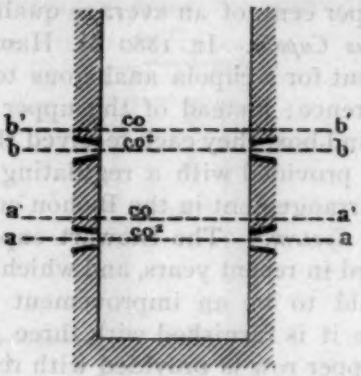
DETERMINATION OF THE NEUTRAL ZONE.

Now when we consider that *theoretically* the melting of 100 pounds of iron with coke having eight per cent. of ash, the coke being all consumed to carbonic acid, requires but four pounds of coke (in case the coke is simply transformed into carbonic oxide there will be required 13·33 pounds), we see that furnaces, having two rows of tuyeres, and which consume from six to twenty-five per cent. of coke for melting (not counting the coke used for "the bed") do not possess all the requirements of perfect cupolas.

It is obvious that the coke above the tuyeres *b b*, in the section *b' b'*, bears the same relation to the CO^2 produced in *b b*, as the coke in the section *a' a'* holds with regard to the carbonic acid developed in the section *a a*, although the quantity of carbonic acid produced at *b b* is less than at *a a*,

* *Engineering*, 1884, p. 56.

for the reason that the tuyeres *b b* are much smaller than those at *a a;* the temperature is, therefore, lower and the



zone of fusion less extended. It is for this reason that we always obtain in the space above *b b*, a certain quantity of CO which escapes at the throat of the cupola.

It is not, however, necessary that the descending materials attain the temperature of the incandescent coke, but only that the ascending gases are hot enough to take fire when in contact with the air. If, therefore, we introduced air by tuyeres above the zone of fusion *b b*, last established, we shall consume the carbonic oxide; but it is in this case very difficult to determine with precision the proper position of a third row of tuyeres in the same horizontal plane, so much the more from the fact that the materials do not always descend in parallel layers, thus permitting the concentration of the combustion of the gas in one plane, and elevating rapidly the temperature of the coke to incandescence, so that a reduction of the carbonic acid will be again possible.

We arrive, therefore, naturally at a new solution, consisting of an arrangement of a series of tuyeres, intended to serve the zone described (which we may call the *neutral zone*), not in one plane, but in a curve embracing a certain height of the cupola.

The Norris System.—This arrangement was already used in a very primitive fashion in 1855, and probably without

a knowledge of the advantages which we are now able to realize by its judicious employment. B. Kerl* mentions a Norris cupola "with a profile enlarged at the top, blown with hot-blast and furnished with six tuyeres arranged in a helix about its periphery, so that the currents of air are thrown into the column of material formed by the charge, at different heights, * * * the descent of the rapid succession of charges is accelerated by the great increase of heat, which also gives a very liquid iron."

This division of the zone of fusion through a certain height did not give the best results, either in regularity of descent of the charge, or in the matter of loss of iron, which he admitted was considerable.

Cupola of Greiner & Erpf.—A new system, having the merits which we have so long advocated, and which is based entirely upon the theoretical considerations herein before explained, was patented by MM. Greiner & Erpf, of Chisnyoviz (*Chisnovoda*), in Hungary, and the cupola was shown by a model at the National Hungarian Exposition at Budapest in 1885.

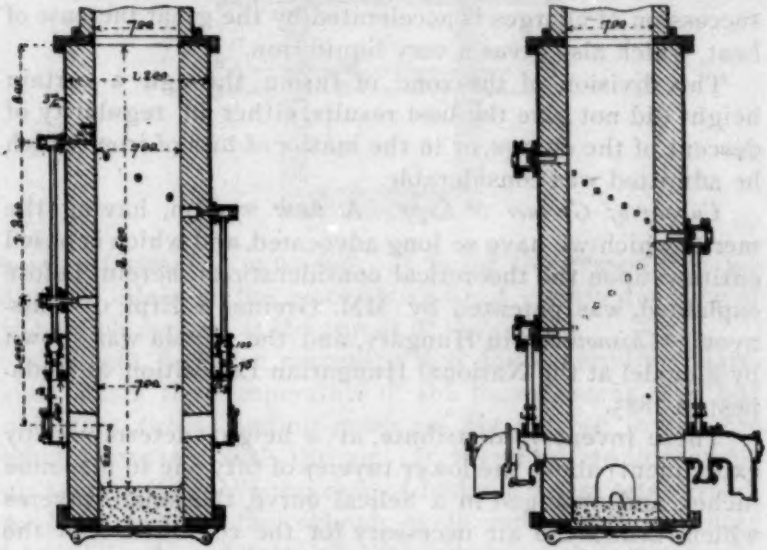
These inventors distribute, at a height (determined by experiment) above the lower tuyeres of fifty-one to fifty-nine inches, and arranged in a helical curve, the small tuyeres which furnish the air necessary for the combustion of the carbonic oxide which escapes from the lower part of the cupola; this gas burns throughout the whole of this zone with a blue flame, and the heat disengaged, which is insufficient to raise the coke to a red heat, is entirely utilized in heating the descending charge.

In the first cupolas erected on this plan, we find the small tuyeres supplied from a wind-box of cast or sheet-iron made in a helical form, which received its air from the same wind-box which supplied the lower tuyeres, or the wind-box received it by means of two vertical tubes furnished with valves (*Fig. 30*). It was therefore not possible to regulate the blast for such of these small tuyeres, or to close any of

* Bruno Kerl: *Handbuch der Metallurgischen Hüttenkunde, 1855*; and *Berg und Hüttenkunde* for the same year.

them according to the rate of melting of the furnace, which would have been a rational method of procedure; and, moreover, the construction of this helical box was complicated and costly.

In the new arrangement finally adopted for all the cupolas of this system recently constructed, the helical box is replaced by a certain number of vertical tubes connected



FIGS. 30, 31. The Greiner & Erpf Cupolas for the complete Combustion of the Carbonic Oxide.

with the wind-box of the lower tuyeres, each being provided with a regulating valve (*Figs. 31* and *32*).

We are practically successful with this construction, in conveniently regulating the pressure and volume of the air delivered by the small tuyeres, so that the gas at the throat of the cupola is barely lukewarm and contains but a minimum quantity, and even sometimes no CO.

In the cupola tried at Chisnyoviz there was but three pounds of coke consumed for the melting of 100 pounds of iron, and the lighting coke for each "heat" was from 386 to 440 pounds.

The pressure of the blast at the lower tuyeres was from

0·70 to 0·98 inches of mercury (9·64 to 13·38 inches of water), which it was not necessary to augment, the number of orifices for the introduction of air permitting a rapid increase of the production for a small additional pressure. At the small tuyeres the pressure is reduced to 7·87 or 6·29 inches of water.

A circumstance of importance, which it is proper to present here, and which is especially characteristic of the Greiner & Erpf system, is this: When the coke used for lighting (the "bed") is being consumed, and the quantity

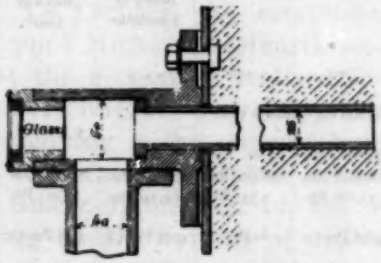


FIG. 32. Detail of one of the small Tuyeres.

of carbonic oxide passing through the neutral zone in front of the small tuyeres is still considerable, it is possible, as has been proved by various experiments, to reduce the weight of coke in the regular charges in a proportion corresponding to the heat developed by the combustion of this carbonic oxide; it is well that we can thus easily explain the apparent anomaly that in this cupola we are able to reduce the consumption of coke for melting to nearly three per cent., whereas, according to theory, it should be in the vicinity of four per cent. This is a rational utilization of the coke used for lighting, the advantage of which is more clearly manifest when but small quantities of iron are melted. We will add, finally, that the Greiner & Erpf system can be easily applied to any existing cupola at an expense of 150 to 200 francs at most.

In the following table will be found a comparison of the results obtained in various establishments which have adopted the system of Greiner & Erpf:

	Chrenvoviz Cupola.*		Westphalia Union Society.		Greiner & Erpf † Société de Construction à Prague	Greiner & Erpf.‡ Fonderie de Schlick Budapest.
	Old System. Two Tuyeres.	The Same Changed to Greiner & Erpf.	Common Ireland Cupola.	The Same Changed to Greiner & Erpf.		
Date of Experiments.	1883.	1883.	1886.	1886.	1885.	1885.
			Mean of 3 months.	*Mean of 7 heats.*		
Total number of charges, ...	207	136	. . .	. . .	414	213
Weight of iron per charge, ...	882 to 1102 lbs.	882 to 1102 lbs.	. . .	. .	882 lbs.	882 lbs.
Weight of coke per charge, ...	74 to 119 lbs.	22 to 33 lbs.	. . .	. . .	35 lbs.	35 lbs.
Total iron charged, .	213,347 lbs.	126,950 lbs.	666,489 lbs.	209,820 lbs.	363,680 lbs.	187,781 lbs.
Total coke charged, .	20,180 lbs.	3,555 lbs.	64,346 lbs.	11,053 lbs.	14,449 lbs.	7,268 lbs.
Coke for melting in per cent. of iron, ...	9·46 Per Ct.	2·80 Per Ct.	9·65 Per Ct.	5·26 Per Ct.	3·95 Per Ct.	3·88 Per Ct.
Total coke ("bed" included) in per cent. of iron, ...	12·28 Per Ct.	6·27 Per Ct.	15·71 Per Ct.	9·18 Per Ct.	5·97 Per Ct.	6·68 Per Ct.

*The cupola with which these experiments were made is represented by *Fig. 30*.

†The dimensions of the cupola of the Société de Construction de Machines à Prague were Diameter, 31·49 inches; two rows of tuyeres, whose distance from the bottom of the crucible was 21·26 and 25·59 inches respectively.

‡The cupola of the Fonderie Schlick de Budapest, had a diameter of 33·46 inches, and a single row of tuyeres 30·7 inches above the bottom of the crucible.

The following corresponding particulars are also given:

(1) Société Anonyme des Hauts Fourneaux et Fonderies de la Louviere (Belgique): Changed two Voisin cupolas of thirty-one and one-half inches in diameter to the Greiner & Erpf system, and realized thereby an economy of thirty-five per cent. in coke.

(2) Ateliers de Construction du Comte Stolberg (Magdeburg): Have one cupola 19·68 inches and another of twenty-seven and one-half inches in diameter, which are run with a consumption of but 3·2 per cent. of coke for melting (not counting the "bed"); at first they reduced this to 3·0 per cent., but the cupolas "chilled" very quickly.

(3) Ateliers d'Andritz de la Société Alpine Autrichienne:

Have a cupola thirty-one and one-half inches in diameter, which consumed 5·01 per cent. of Westphalian coke.

(4) The experiments very recently made at the Cockerill establishment, at Seraing, show an economy of coke, arising from the substitution of the Greiner & Erpf system in place of the ordinary method, for the cupolas of their Bessemer steel works, of twenty-five per cent.; these cupolas perform perfectly with a pressure of 7·66 inches of water.

We will add finally that the system of Greiner & Erpf is being erected in various important works, among which we will mention: Le Creusot, the establishments of MM. Ferry et Curricque à Micheville (Meurthe-et-Moselle), etc.

We see that the economies realized by arranging the tuyeres in a helical line are very important, and that the system we are studying is the one which up to the present time gives the best practical results—embodying a simple, judicious and timely application of the most important principle relating to the working of cupolas—that of the *total combustion* of the carbonic oxide.

Notwithstanding all our endeavors, we have not been able to obtain an analysis of the gas from the throat of this cupola, and this circumstance is to be regretted, as such an analysis would theoretically confirm the advantages of this apparatus, which have already [been established in practice.

VII.

CUPOLAS FIRED WITH GAS.

In all the cupolas before described the fuel is in direct contact with the metal being melted, and it is always necessary to avoid the use of a coke containing impurities, especially when the iron is intended for the manufacture of steel.

In searching therefore for a means of separating the fuel from the metal, we find no agent superior to gas, which is the final condition of all fuel whatsoever.

The Dufréné Cupola.—The cupola of H. Dufréné (Paris,

1881) was furnished with a gas-producer, situated in front of the apparatus (*Figs. 33* and *34*); the pig-iron and scrap were

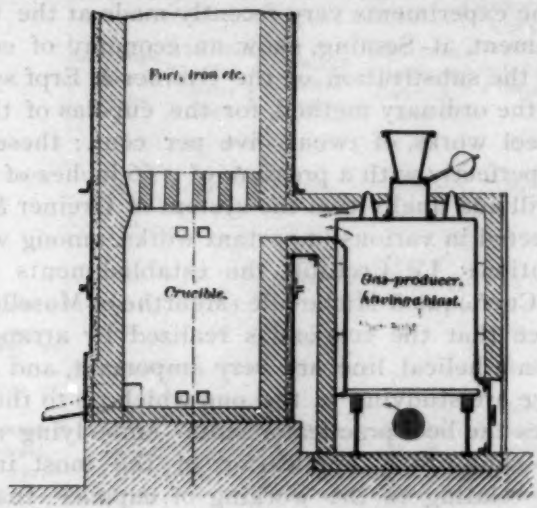


FIG. 33. The Dufrêné System.

placed above the crucible upon a gridiron made of a good quality of refractory material, and the gas (previously mixed

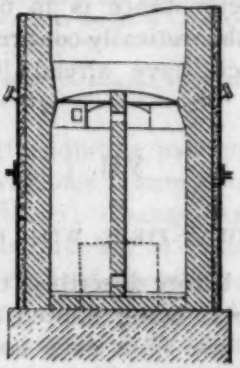


FIG. 34. Section through the Cupola.

with air, heated by circulating around the walls of the gas-producer), traverses the gridiron and the iron piled upon it.

The Besson Cupola.—M. F. Besson, of Lyons, patented, in 1881, a gas cupola for rapid melting, furnished with a kind of blow-pipe (*Fig. 35*), which developed a very great heat in

the apparatus; and there was besides above the crucible a special tuyere intended for the refining of the iron.

The Bramhall System.—In 1884, M. C. Bramhall, of Sheffield, proposed a form of gas cupola, having a regenerator with four chambers, of the kind only used in the Siemens furnace, which were traversed right and left by the gas from the throat of the cupola; the system supposed also that

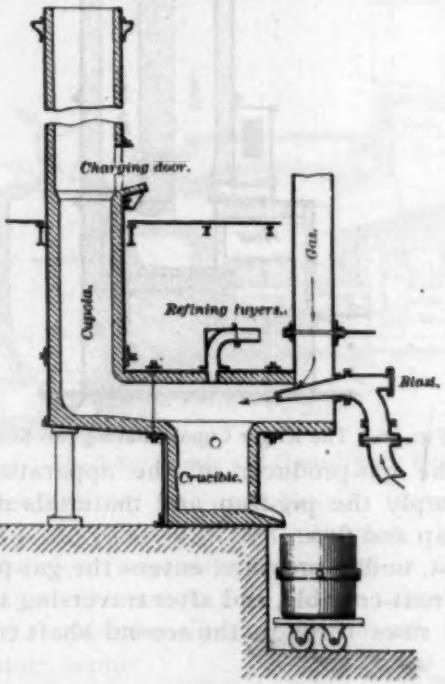


FIG. 35. The Besson Cupola.

this gas is at a comparatively high temperature, which would evidently be the result of bad management of the cupola. In all these cupolas it is necessary to watch carefully and maintain a reducing flame when we wish to obtain gray iron, but when we melt iron for puddling, it is easy to refine it by means of an oxidizing flame, but we are subject in this case to considerable loss.

The Krigar Cupola, with two Shafts.—A special system, patented by M. Krigar, of Hanover, already hereinbefore

mentioned, may be also regarded as working with gas, with this very important difference, that the melted iron comes in contact with the ashes of the coke at the lower part of the apparatus, before it enters the crucible in its front.

This cupola is composed of two distinct shafts (*Fig. 36*); the one closed at its top is intended to receive the fuel and

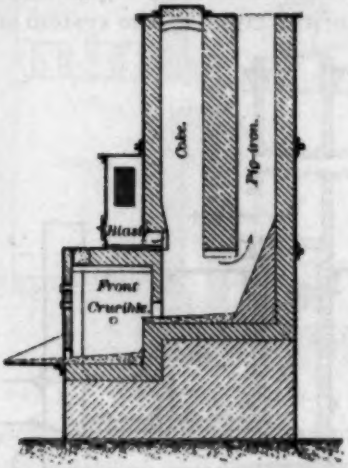


FIG. 36. The Krigar Cupola, having two Shafts.

serve as the gas-producer of the apparatus; the other receives simply the pig-iron, and materials mixed with it, such as scrap and flux.

The blast, under pressure, enters the gas-producer shaft above the front crucible, and after traversing the lower part of the fuel rises through the second shaft containing the iron.

We have given a very imperfect account of the advantages which are offered by this arrangement.

The Riley System.—The most interesting and most practical application of gas for melting in a cupola, is that made by M. Riley, of the Blochairn Works, at Glasgow,* for the manufacture of open-hearth steel; under this system the duration of the operation in the reverberatory furnace is reduced, by introducing the iron in a liquid state.

M. Riley arranges in convenient relation to the open-

* Autumn Meeting British Iron and Steel Institute, 1885.

hearth furnace, a cupola fired by gas generated in a gas-producer furnished with a blast; in this cupola is charged the pig-iron, and then the steel scrap, without any solid fuel (*Fig. 37*).

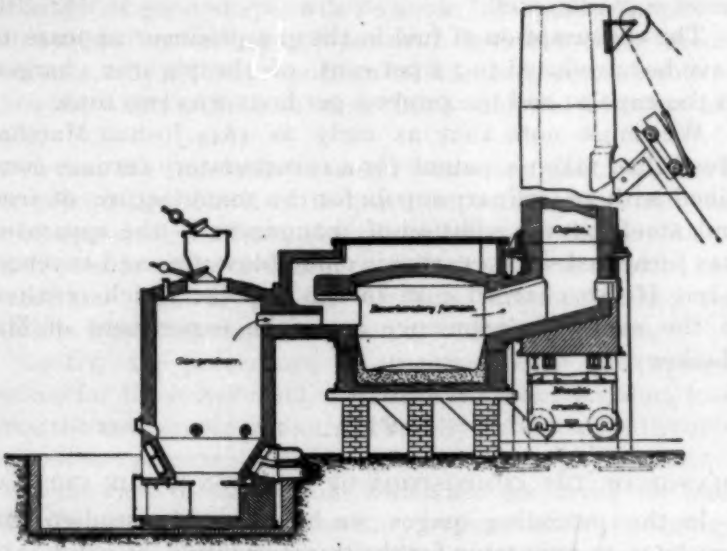


FIG. 37. The Riley Cupola and Open-Hearth Furnace.

The production of an open-hearth furnace is thus augmented in the vicinity of ten per cent.; the principle advantage of this arrangement consisting in the fact that the oxidation of the carbon and silicon takes place in the cupola, and the operation in the open-hearth is, therefore, very much more rapid.

M. Siemens * mentions some experiments of similar kind tried at Landore, by M. Hackney, these experiments, it appears, were not successful, because they charged coke also in the cupola, the result being that the decarburization could not take place there instead of in the reverberatory furnace, in which the action of the oxidizing flame upon the bath of metal covered with slag is too slow.

With the apparatus at Blochairn, the melted iron is run into the reverberatory furnace two hours after turning on

* Autumn Meeting British Iron and Steel Institute, 1885.

the gas; at first the charge of the cupola was pig-iron alone, then ten per cent. of steel scrap was added, and the addition was continued until it amounted to ten tons for each ton of pig-iron; but in this case the lining of the furnace did not resist corrosion well.*

The consumption of fuel in the gas producer appears to have been reduced to 7·2 per cent. of the pig-iron charged in the cupola; and the product per hour was two tons.

We must note that as early as 1844 Joshua Marshal Heath had taken a patent for a reverberatory furnace combined with an ordinary cupola for the manufacture of iron and steel, by the addition of manganese †—the apparatus was furnished with a carbonic oxide blow-pipe and tuyeres; —but Heath charged coke in the cupola; which resulted in the same inconvenience as in the experiment of Mr. Hackney.

VIII.

CHANGE OF THE COMPOSITION OF THE IRON IN THE CUPOLA.

In the preceding pages we have simply studied the cupola as an apparatus for the transformation of solid into liquid iron by means of fuel, either coke or gas, without fixing our attention especially upon the chemical composition of the iron and its mixtures.

The percentage of foreign matter in the pig-iron which is to be remelted in a cupola being, however, a very important factor—either when we intend to make castings or more especially when the iron is intended for the manufacture of open hearth or Bessemer steel—it has been taken account of for certain purposes. In case of castings the percentage of carbon plays a less important part than that

* The employment of liquid iron in reverberatory furnaces has often been tried, especially for puddling, but it has always failed, in consequence of the rapid wear of the bottom of the furnace. Recently, again (1885), the Dujardin system has been patented in Belgium, and this puddling furnace appears to have worked without difficulty and economically.

† Mentioned by M. H. Bessemer at the Autumn Meeting of the British Iron and Steel Institute, 1885.

of phosphorus and sulphur. We know that a certain proportion of phosphorus is necessary to ensure the fluidity of the iron so that it will reproduce the form of the moulds with exactness; and that if it is in excess the castings, although of good shape, will be weak. A small quantity of sulphur, not exceeding 0·06 per cent. does not cause inconvenience, but if this proportion is exceeded, we are liable to have blow-holes, the iron runs thick and the castings are bad.

In case the iron is to be used for the manufacture of steel the percentage of carbon is most important, especially for Bessemer steel, and the decarburization in the cupola, or otherwise, must be avoided, or reduced to a minimum, and sometimes the carbon may require augmentation; the same is true with regard to the percentage of silicon.

Lastly, the percentage of manganese in the spiegel melted for Bessemer steel, cannot be reduced without loss, since the manganese irons are generally purchased with reference to the percentage of manganese which they contain.

In the case of those irons which are employed for puddling, we should, on the contrary, reduce their percentage of carbon, and those cupolas having tuyeres directed downward towards the crucible, as well as those having special tuyeres for refining (Besson) are recommended, in case refined iron is used for this operation; an excess of manganese is also injurious, because it makes a cinder of very great fluidity, which reduces the yield.

The employment of iron melted in a cupola for puddling is yet very much restricted, and it is not necessary to say more of it here.

Limestone.—A means used everywhere, regardless of the form of the cupola, to prevent the too great decarbonization of the iron when it passes through the zone of fusion, and encounters a current of gas more or less oxidizing, consists in the addition to the charge of a certain proportion of limestone, from thirty-three to sixty-six pounds per charge; the proportion is regulated by the per cent. of ash in the coke, so as to make with the ash a cinder of a composition suitable to envelop the particles of iron within the zone of

fusion and prevent their oxidation, and at the same time reduce the loss.

If it is considered desirable to avoid the presence of sulphur in the iron, when the coke used contains it, we endeavor to obtain a basic cinder which absorbs the sulphur of the coke instead of allowing it to pass into the iron.

Quality of the Fuel.—The quality of the fuel charged into the cupola, therefore, plays an important part from a chemical, as well as from a physical point of view.

The sulphur contained in the ash of the coke tends to pass into the iron, and we see that that may be prevented by a basic cinder, which we make by charging a large quantity of limestone, which necessitates a large consumption of fuel, and augments the net cost.

This is also true when the coke is very ashy and of feeble tenacity, as it is then crushed in the charge, whose descent is irregular, and the coke dust produced is raised by the blast and thrown out of the chimney without having been utilized. The porosity of the coke is also a factor to be considered, inasmuch as coke which is very dense produces more carbonic acid than a porous coke, which presents a large surface of contact for the air.

Oxygen in Excess.—The presence of oxygen in excess in the gas has a very unfavorable influence, because the decarburization of the iron is very great and at the same time its waste is increased, but, however, when the zone of fusion is of small extent, this waste is diminished, for the iron is exposed for a less time to the action of the gas; which appears to be the case, for example, in the Herbertz cupola.

Percentage of Manganese.—With regard to the percentage of manganese in the iron, and especially in spiegel, it is very much reduced in the cupola, as a great part of the manganese passes into the slag, especially when the temperature is low; then, again, considerable manganese is lost in case the cinder is acid, and the temperature too high, accompanied with a low pressure of blast.

The analysis published by M. de Köppen* relative to

* *Dingler's Polyt. Journal*, 1879. Vol. 232. p. 53.

the fusion of spiegel in a cupola, indicate an increase of Si, C, Ph, and S, and a decrease of Mn.

The augmentation of the former substances results in reality from a waste of iron during melting, which was very great, and, as regards the carbon, probably there was a heavy charge of coke with ordinary iron.

The proportions in which the three most important substances varied in five different experiments are given by M. de Köppen as follows:

Amount of	I		II		III		IV		V	
	Before.	After.	Before	After.	Before.	After.	Before.	After.	Before.	After.
	Melting in the Cupola.									
Si, per cent., ...	0·14	0·50	0·12	0·49	0·12	0·42	0·40	0·66	0·33	0·41
Mn, per cent., ...	14·81	8·96	14·25	10·52	14·98	11·06	16·24	10·98	14·93	12·03
C, per cent., ...	3·98	4·13	4·40	4·62	4·48	4·60	4·62	4·96	3·43	3·67

The cinder of these meltings has an average composition of 33·63 per cent. SiO_2; 21·45 per cent. CaO; 11·73 per cent. Al_2O_3; 20·47 per cent. Mn., and 5·95 per cent. Fe.

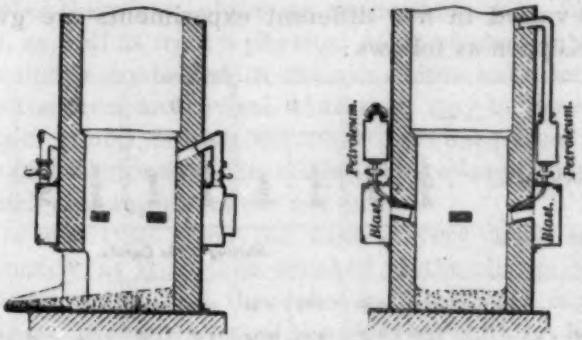
THE INJECTION OF VARIOUS MATERIALS BY THE BATTY SYSTEM.

It has been attempted to modify the composition of the iron by the introduction of a variety of materials in the cupola; Dingler* mentions a cupola invented by Batty, of New York, in which it is proposed to introduce, by the tuyeres, pulverized fuel, such as the carbon deposited on the interior of gas retorts, or the residue of the distillation of petroleum, which leave no ashes. Batty proposes thus to avoid the oxidizing action of an excess of blast, by immediately combining all the oxygen with the injected carbon, thus making a neutral or even a reducing flame; promoting the formation of a "noze" on the tuyeres, obtaining a very

* *Dingler's Polyt. Journal*, 1877. Vol. 224, p. 105; *Polytechnic Review*, 1877.

high temperature and reducing the waste; which results, it seems to us, have been attained by very much more simple means.*

The Voisin-Bichon Cupola.—Another system, which has been much used in France, is the Voisin-Bichon; this consists in the injection of petroleum, or other heavy oil, by means of tubes of small diameter extending from two reser-



FIGS. 38, 39. The Voisin-Bichon Cupola.

voirs of the oil, and entering the cupola through two opposite tuyeres of the lower row; a tube of larger dimensions enters the shaft at a certain height for the purpose of heating the oil by the gas, so that it will readily flow to the lower tuyeres (*Figs. 38* and *39*).

The principal advantage of this arrangement consists in the possibility of obtaining very high temperatures, for the fusion of large masses, by the employment of these heavy oils.

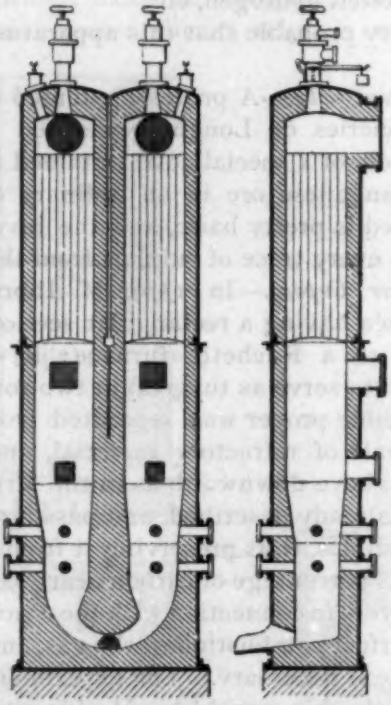
No details have been given relative to the experiments which have been made with this apparatus; these would have been interesting, especially if they showed the net cost.

In the Voisin-Bichon each of the tuyeres of the upper row is served by a special tube, by which the admission of blast can be regulated at pleasure, and we are told that by closing the upper row of tuyeres, at the beginning and end

* The injection of powdered fuel has been tried repeatedly; in blast furnaces in Bessemer converters (the Braconnier process for example), but the results have not been commensurate with the high cost of the apparatus employed.

of a "heat," the iron was brought down very hot and that it was possible to introduce a charge of iron at the end of the heat, without any fuel.

The Herdlitschka System.—An arrangement, very scientific and practical, invented by M. Herdlitschka,* consists of two communicating cupolas, joined by their crucibles (*Figs. 40* and *41*). These cupolas are intended to work alternately, and are each furnished with a regenerator placed in the



FIGS. 40, 41. The Herdlitschka System.

upper part of its shaft; the various materials intended for the purification of the iron are introduced above these regenerators by a steam injector.

After the fusion of the iron in one of these compartments, and the metal collects in the common crucible, the openings

* *Dingler's Polyt. Journal*, 1880. Vol. 4, p. 318. (Whatever else this system may be, it does not appear very "practical" to the translator. W.F.D)

of this compartment are all closed, and the proper injector is put in action, forcing the chemical reagents through the regenerator (where they are heated), and causing them under pressure to traverse the liquid iron; it is, however, necessary to previously remove, through a special door, the cinder and unconsumed coke from the compartment. M. Herdlitschka claims to thus deprive the metal of a great part of the sulphur and phosphorus, by the injection of steam, carburetted hydrogen, etc.

It is not very probable that this apparatus has been put in operation.

Manganiferous Coke.—A process, patented in 1884, by the Société des Aciéries de Longuy, consisted of the employment in a cupola of a special coke, obtained from a mixture of coal and manganese ore in an ordinary coke oven; the cinder produced is pretty basic, and the inventors say that it will remove every trace of sulphur from the iron.

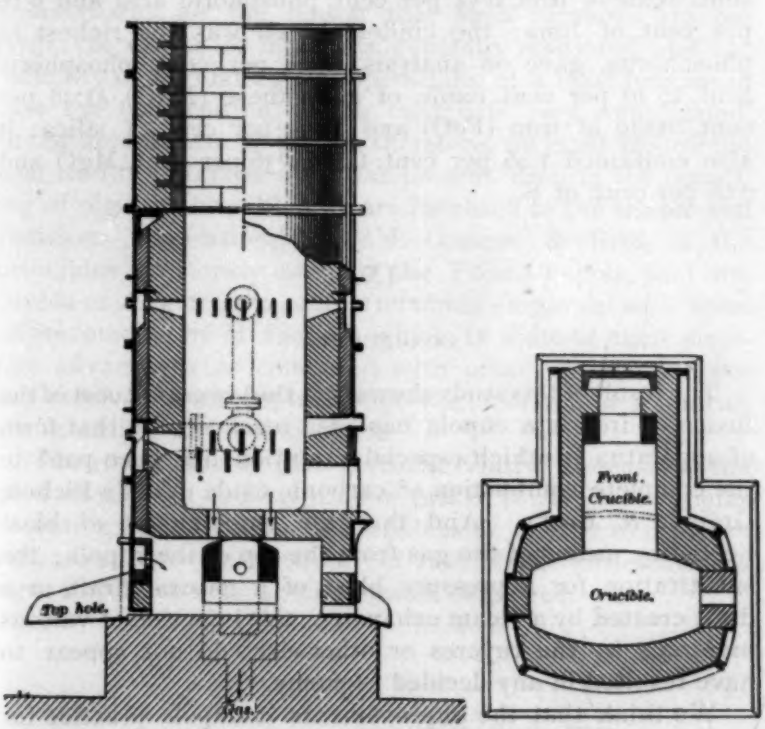
The Ibbruger Cupola.—In 1879, M. Ibbruger* built at Norden a cupola having a rectangular section, with convex sides, similar to a Rachette furnace; it was fitted with thirty-six slits (to serve as tuyeres) in two rows (*Figs. 42* and *43*). The crucible proper was separated from the zone of fusion by a wall of refractory material, and the gas was directed from above downward, as in the Krigar cupola, by aspiration, as already described, and passing over the metal in the two crucibles, thus preserving it from oxidation and maintaining its percentage of carbon nearly constant. A supplementary tuyere in connection with the crucible is intended to ensure a perfect combustion of the gas, and to allow of an oxidizing flame if necessary. The experiments, which have been made with this cupola by M. Jüngst, of Gleiwitz,† show that the same iron melted three or four times improved in quality by the graphite being slowly transformed into combined carbon. The pressure of the blast was 24·4 inches of water. The total consumption of coke was ten per cent. This cupola will melt with advantage as much as forty per

* *Dingler's Polyt. Journal*, 1880. Vol. 245, p. 14.

† *Eisen Zeitung*, 1885, p. 678.

cent. of scrap placed in the crucible or mixed with the liquid iron. The results appear to have been satisfactory.

The Krupp System.—We speak lastly of an apparatus, patented in 1878 by M. F. Krupp, intended especially for the purification of iron.* It is based upon the principle, that if we melt in a furnace having its shaft walls made of neutral bricks, and its crucible lined with basic or neutral material, the liquid iron, when mixed with basic oxide of iron, with or without oxide of manganese or lime, loses in great part its manganese, silicon, sulphur and phosphorus.



FIGS. 42, 43. The Ibbruger System.

The iron, mixed with ore (FeO), is melted at first in a cupola furnished with two rows of tuyeres, and which is on a higher level than the purifying cupola.

The experiments made in a small temporary apparatus

* *Dingler's Polyt. Journal*, 1880. Vol. 235, p. 373.

have given results sufficiently remarkable to justify us in reproducing them here:

Percentage of	C	Si	Mn	Cu	P
Impure iron, ...	3·730	0·470	3·560	0·250	0·600
Purified iron, first trial, ...	3·000	0·004	0·128	0·250	0·136
Purified iron, second trial, ...	3·400	0·005	0·218	0·250	0·187
Purified iron, third trial, ...	3·400	0·002	0·470	0·250	0·210

The ore employed for purification contained 98·20 per cent. oxide of iron, 0·54 per cent. phosphoric acid and 0·10 per cent. of lime; the cinder, which was the richest in phosphorus, gave on analysis: 5·28 per cent. phosphoric acid, 26·30 per cent. oxide of manganese (MnO), 41·28 per cent. oxide of iron (FeO) and 17·60 per cent. of silica; it also contained 1·46 per cent. CaO, 0·36 per cent. MgO and 0·66 per cent. of S.

IX.

CONCLUSION.

The result of this study shows that the lowest net cost of the fusion of iron in a cupola has been reached with that form of apparatus in which especial attention has been paid to the complete combustion of carbonic oxide (Voisin-Bichon, Greiner & Erpf). And that the employment of blast heated by means of the gas from the top of the cupola; the substitution, for a pressure blast, of a natural draft, or a draft created by a steam exhauster; the injection of various materials by the tuyeres or otherwise, do not appear to have resulted in any decided economy.

We think that the improvements in cupola practice for which it is still profitable to search, relate to the modification of the composition of the iron, by the removal of its impurities, with a view to its final employment for the manufacture of steel or for puddling.

These results can be attained by the addition of various materials, either to the charge or in the crucible; or else by

the employment of a special lining for the walls of the cupola; which, last, would not be applicable to ordinary cupolas intended merely for melting iron; but more properly to such improved siderurgical apparatus intended as a substitute for the expensive and complicated methods of dephosphorization in a converter or basic open hearth, on which metallurgists have in recent years concentrated all their efforts. It is true that it would be more direct, if we could obtain the same results in the blast-furnace; but the numerous researches made in this direction have been unsuccessful, for the reason that such furnaces are too large, the choice of materials generally restricted, and the difficulty of regulating the operations of a blast-furnace in case the composition of the charge is very complicated. In the actual state of things, therefore, we must record the best results obtained up to the present time in the remelting of pig-iron, for which we are indebted to the simple and judicious application, by MM. Greiner & Erpf, of the principles previously used in the Voisin cupola, and the cupola at Angiers, etc., and afterwards employed with some improvements by M. Bichon, which, in spite of their manifest advantages as compared with other apparatus, have not received from engineers of steel works and foundries the attention which they merit.

The accompanying table gives the relative dimensions, the product and the consumption of fuel of thirty-three cupolas of various construction, and enables us readily to compare the advantages in economy of fuel of the different systems that have been actually much employed.

THE NICARAGUA CANAL.

By COMMANDER H. C. TAYLOR, U. S. Navy.

[*A paper read at the Stated Meeting of the* FRANKLIN INSTITUTE, *Wednesday, October 15, 1888.*]

JOS. M. WILSON, President, in the Chair.

Commander TAYLOR spoke as follows:

MR. PRESIDENT, AND MEMBERS OF THE INSTITUTE:

It appears that, after all, Columbus was not mistaken in sailing westward from Spain in search of a convenient route to the East Indies.

The intervening continent, which checked his progress and disappointed his successors in American exploration, made his avowed attempts to reach the Indies a complete failure, though the memory of this failure was lost and obscured in presence of the glory of a greater success, the undreamed glory of a new world.

It is a pleasing thought, that four centuries later, perhaps in the very year 1892, we shall see the wisdom of that valiant spirit justified, and European fleets sailing westward from Spain through an isthmian ship-canal, as the most convenient route to the far East. The mind dwells with satisfaction upon this justification of the great navigator, and sees, with a singular pleasure, ships coming out of Cadiz, dropping almost immediately into the soft current of the northeast trade-winds, and blown by them smoothly across the Atlantic and Caribbean, between the islands of the West Indies, and quite into the entrance of a Central American ship-canal; issuing thence into the same belt of gentle favoring winds, and carried by them across the broad Pacific to those rich coasts and islands of the far East which were ever such powerful magnets to the earlier navigators. Nor is this pleasing thought any longer an unreasonable one. That ships shall cross the isthmus from sea to sea has been decided. The clamor of commerce and its shipping can no longer be disregarded.

Transit across the narrow lands of Central America is certainly to be provided, and the only questions are when, where and how.

The search for a practicable canal route succeeded to the long persistent examination which had caused explorers for so many years to penetrate every inlet from Newfoundland to La Plata, in the hope of finding the strait which they confidently believed nature had provided as a means of communication between the oceans.

"Men," said Humboldt, "could not accustom themselves to the idea that the continent extended uninterruptedly from such high northern to such high southern latitudes." From the year (1513) when Nuñez de Balboa first looked upon the wide sweep of the Pacific, a century was occupied in fruitless efforts of gallant and capable men to discover that strait which nature should have placed there—but did not.

The Cabots worked in the north. D'Avila, under secret orders of the Spanish king, scrutinized eagerly the isthmuses and the Spanish Main; while De Solis, under similar instructions, explored the coast of Brazil, and while hopefully ascending the great estuary of La Plata, was killed by the natives of that region. Ponce de Leon sailed hundreds of miles northward from Panama on the same errand; Cabrillo and other lieutenants of Cortez groped north and west from Tehuantepec, as far as the vicinity of the present Monterey and San Francisco; and Cortez himself, under the urging of his royal master, King Charles V, of Spain, struggled against much obstacle and disaster to achieve the desired discovery. When, however, the Gulf of California was found to have a head at the mouth of a great continental river, the intelligent Spanish explorers, already doubtful, could no longer believe in the existence of any communication between the seas, and the "secret of the strait" faded away into the dreamland of legend and fable. Other nations than Spain still hoped. As late as 1607, we are told by Bancroft, Virginia colonists were ordered to seek communication with the South Sea "by ascending some stream which flowed from the northwest," and that it was

in ascending the Chickahominy with this end in view that Captain John Smith was captured by the natives; and thus another touch of interest is added to the adventurous record of this man of ordinary name and extraordinary life.

The strait was indeed an idea difficult to surrender. It *ought* to be true, they said. The seas are so close together for 1,000 miles. Commerce between "Cadiz and Cathay" so greatly needs it. It *must* be so. That it should not be was, in the words of the writers of that day, "repugnant to the interest of humanity." The "secret of the strait" *must* be disclosed.

The world moving, like all large bodies, slowly toward conviction, did become at last convinced that nature had not pierced the barrier for our use and comfort, and this conviction once forced upon it, plans for an artificial channel began soon to be suggested. The idea had been touched upon by Balboa, Cortez and Saavedra, but the first record we have of a practical suggestion is that of the Spaniard Gomara, who urged the idea upon Philip II in 1551, but the son was not the father; nor were such leaders as Cortez to be found, even had the spirit of Charles V still animated the actions of the Spanish throne.

From this time forward, the Spanish government seemed disposed rather to smother than to encourage any efforts to connect the oceans. As the old-time Spanish vigor departed, the feeling grew that if any good route were found, it would only be snatched from them by some of those daring Drakes and Grenvilles, who, roaming the seas at the head of brave and reckless companions, sought every opportunity to insult Spain and plunder its colonies.

A long period now passed, during which no interest was evinced in the canal question. The mystery with which the Spanish government had wished to cover it was complete. If the desire for knowledge came later, the failing vigor of that nation stood in the way of any successful investigation.

It was left for Humboldt to reawaken an interest among the nations, and to indicate localities where favorable results would be most likely to be met with by the explorer

and surveyor. In his opinion, the valley of the Atrato and the Isthmus of Darien were points where examinations should first be made. Later we shall see how thoroughly these localities have been surveyed, and with how little success.

Before Humboldt's time Admiral Horatio Nelson had become thoroughly interested in the San Juan River and Lake Nicaragua, as being the great route for future transit between the oceans, and one of his few reverses was sustained in attempting to gain a foothold in Nicaragua for the British navy, being defeated and driven back while attempting a hostile advance or reconnaissance up the San Juan.

In 1825 Nicaragua invited the co-operation of the United States in the construction of a canal by way of Lake Nicaragua and the River San Juan, but with no satisfactory results. In the same year Mexico caused a rough survey to be made of the line *via* the Coatzacoalcos River and the Isthmus of Tehuantepec, resulting in an official report that the "canalization of this isthmus was problematical and gigantic."

Later, in 1828–29, a survey was made under orders from General Bolivar of a route substantially the same as that of the present railway between Aspinwall and Panama. Nothing was effected by this action, except to put an end to the popular error that the mean levels of the oceans on opposite sides of the isthmus differed appreciably. There are still some, I believe, among those who have not given their attention to this subject, who are yet ignorant that differences are caused only by tides, winds, barometric pressures, and other temporary disturbing causes, and that the levels of the two seas may be regarded as practically the same.

Many other attempts were made in the ensuing years, and with uniform lack of success. In 1830, the Netherlands, beginning fairly enough, were obliged by the revolution in Belgium and its separation from Holland to give up the project. In 1835, President Jackson appointed Mr. Charles Biddle as special agent to promote the idea of an isthmus canal, and to visit the Central American countries for that

purpose. Mr. Biddle met with many difficulties, and returned to the United States with nothing accomplished of value, and from this time the projects became too numerous to be even touched upon in a paper of this scope. M. Guizot, under Louis Philippe, urges interoceanic canal questions upon the attention of the Chamber of Deputies. A bishop of San Salvador goes to Rome and urges the importance of a canal upon the Pope. All of no avail; but in 1849, a success is scored, not for a canal, but for the Panama Railway.

This method of transit, of vast service to commerce, has, however, by providing an imperfect system, retarded the realization of that dream, long cherished, of a water connection between the oceans.

We must not omit, in this brief sketch, to record the attention which Louis Napoleon gave to the project. He studied it carefully, and had at one time thoroughly prepared himself to assume the presidency of the "Canal Napoleon de Nicaragua." His views are best set forth by quoting from his own writing in the magazines of that day, before he became Emperor of the French.

"The geographical position of Constantinople is such as rendered her the queen of the ancient world. Occupying as she does the central point between Europe, Asia and Africa, she would become the *entrepôt* of the commerce of all these countries, and obtain over them an immense preponderance; for in politics, as in strategy, a central position always commands the circumference. There exists in the new world a state as admirably situated as Constantinople. We allude to the state of Nicaragua. As Constantinople is the centre of the ancient world, so is the town of Leon the centre of the new, and if the tongue of land which separates its two lakes from the Pacific Ocean were cut through, she would command, by virtue of her central position, the entire coast of North and South America.

"The State of Nicaragua can become, better than Constantinople, the necessary route of the great commerce of the world, and is destined to attain an *extraordinary degree of prosperity and grandeur*."

Here, at Brito, instead of Leon, will rapidly be created one of the great world centres of industry, an *entrepôt* of vast international commerce, a focus of interchange for the products of the globe.

We must now, having glanced briefly at the past history of this great problem, make a rapid review of the work of to-day, and consider the various routes which have been examined during the last few years. Although the boiling-down process of precise instrumental surveys has reduced these possible lines of transit to three, Panama, Nicaragua and Tehuantepec, and although the further process of actual digging and building will, it is believed, soon rule out Panama and Tehuantepec, leaving only Nicaragua, yet many other routes, methods and plans have been examined, and no portion of the isthmuses can be said to have been neglected.

Beginning at the south, we find the Atrato River, recommended by the great Humboldt, rising in the mountains of Western Colombia, and pursuing a northerly course to its mouth in the southwestern corner of the Caribbean. Although its waters empty into the Eastern Sea, its course is parallel to the Pacific Coast, and only about fifty miles from that ocean. The main stem of the Andes, whose eastern slopes it drains, separates it throughout its course from the Pacific. This range is throughout this portion not of great elevation, and numerous tributaries afford, in their valleys, easy grades from the Atrato to or toward the crest of the divide.

Humboldt was told of vessels passing from the head waters of the Atrato to those of a small stream flowing southwest into the Pacific, by means of a short canal. Later examinations show that the vessels were canoes, the canal, if not mythical, was a ditch, and that a long and high portage intervened over which the canoes were dragged. Lower down the Atrato several lines of levels were run across the divide, with much care and labor, following the lines of some of the principal tributary streams entering from the westward. In these it was found necessary that

the summit levels should include tunnels many miles in extent, high enough to accommodate ships with at least the lower masts left standing, and involving enormous expense. Attempts were also made to connect the Gulf of San Miguel with Caledonia Bay on the Caribbean side; and at a point farther west, to connect the Gulf of San Blas on the Caribbean with the Bayano River, emptying into the head of Panama Bay. Here again long tunnels or other formidable obstacles were soon revealed as the lines of levels were carried across.

Next came the line of the Panama Railroad, and here high hopes were entertained, for a railroad was already there, and the Chagres, a large stream, debouching near Aspinwall, has its source well over toward the Panama or Pacific side of the isthmus. After careful surveys on this line, it was decided that a lock canal was possible, though difficult, costing over $100,000,000, and meeting with trouble in supplying water for its summit level. A canal at the level of the sea was deemed impracticable, it being considered that the violence of the freshets in the Chagres placed it beyond successful engineering control.

The surveys of these routes had been carried on by our Government, but the interest felt to-day in the Panama Canal project makes it proper for me to notice other work in that locality, for French enterprise had begun to stir, and a speculative company, known as the "International Society of the Interoceanic Canal," had been formed in Paris in 1876.

I will not fatigue the INSTITUTE with the monotonous details of continuous blunders. It is the wonder of modern civilization that Count De Lesseps should have been able to raise $420,000,000 to perform a work which was known to the world, outside of France, as impracticable if not impossible. Briefly, we will say that certain French gentlemen obtained from the United States of Colombia a concession, and having interested M. De Lesseps in the project, persuaded him to assume the leadership of the Panama sea-level canal. De Lesseps, in 1879, caused the French Geographical Society to assemble, by invitation, an International Canal Congress. This Congress, thoroughly under

his influence as to its committees, and largely so as to the body of the Congress, decided, against the earnest protest of the ablest engineers in the world, to approve the sea-level plan at Panama. The development of the project since that time can be read in the newspapers of the day. The company owes about $420,000,000, with an interest and fixed charges of about $22,000,000 per year. I do not understand that M. De Lesseps claims that more than one-fifth of his work is completed, and my own studies of the subject, coupled with personal observations in the earlier part of the work, convince me that one-tenth is nearer the actual amount accomplished. Lately a change has been made in the plan, and a temporary or provisional lock canal is proposed, and work is now going forward on that basis.

A glance at the comparative profile of Panama and the comments of *Engineering News*, of June 2, 1888, thereupon, to be found in the Appendix, will show that, although much less remains to be excavated under the lock plan than under the sea-level plan, nevertheless it bears such a proportion to the effective cube already excavated, that we may safely say that only thirty per cent. is done toward a lock canal.

In all these estimates we leave to one side the question of the control of the Chagres River, a problem which seems hopeless to many of the best engineers.

These facts do not surprise those who have studied the question. Great engineers warned Paris and the world of just such a disaster at the Paris Congress, while they urged Nicaragua upon their attention as being an entirely feasible, economical engineering project. We know why they were not listened to; we know how the French clustered loyally about their famous De Lesseps; how he, totally ignorant of the topographic and climatic difficulties, flushed with success and impatient of contradiction, would hearken to nothing but a French plan, executed by Frenchmen.

We cannot doubt the brilliancy of De Lesseps' vigorous intellect. His long career vouches for it. But Napoleon was brilliant, and yet committed the foolishness of invading Russia. He was great, but he had his Waterloo. De Lesseps is great, but he has his Panama.

Omitting Nicaragua, for the present, and referring briefly to the lines in Costa Rica and Honduras, the former connecting Chiriqui Lagoon with the Gulf of Dulce, and the latter crossing from the Bay of Honduras to the Bay of Fonseca, they may be summed up by stating that excellent locations for railways were found here, with good harbors at the termini, but that the elevation of the mountain ranges in the vicinities made canals impossible.

Passing on still farther to the north and west, we come to the northernmost of the isthmuses, that of Tehuantepec. Cortez satisfied himself with regard to its usefulness as a land transit, and sent by that line much of the equipment arriving from Europe for his Pacific fleets fitting out for exploration and conquest. Later on, when no longer used, the world fell again into ignorance concerning it, and the ancient legends of a strait existing here gained a fresh credence until as late as the middle of the last century.

The late Captain Eads proposed, as a canal here was impossible, to take sea-going ships, loaded with heavy cargoes, out of the water, lift them upon a cradle, and carry them by rail across six hundred and fifty feet of elevation, through swamps and across streams, and finally to lower them into the water on the other side of the isthmus.

The mass of engineering opinion regards the building of embankments, the management of grades and turnings, to be, under this heavy load, difficult and perhaps impossible. The mass of nautical opinion considers the lifting and carrying of heavy ships, loaded with railroad iron or other heavy weights, to be dangerous in the highest degree to the integrity and safety of the ships' hulls.

There is more than one way of avoiding breaking bulk easier and simpler than this. Ships for this isthmus trade can be fitted with interior decks on which rails are laid for cars of the lightest and snuggest construction, stowing closely together, and losing but little stowage room by their interstitial spaces. Cargo may be stowed in them, and these cars, of a size to fit a narrow-gauge road across the isthmus, can be hauled out through the bow or stern ports, in a dock arranged to float the ship higher or lower, as

needed, in order to bring its decks in succession at the level of the shore tracks.

Those cars would be run across a cheaply constructed narrow-gauge railway, and run into the hold of a ship on the other side of the isthmus, fitted in the same way to receive them.

Some little stowage space would, of course, be lost, but this loss would be slight compared with the enormous tolls each vessel would have to pay to allow dividends on the expensive railway needed to carry bodily a large vessel and her cargo.

This is not a specially good project; but it is one of many plans which are more feasible, economical and sensible than the project of a ship railway.

It is a pleasure, after describing these problematical locations, these mistakes, these costly blunders, to have the privilege of describing briefly to this distinguished gathering the project of a Nicaragua Canal. The value of this route has been long known. Here, in Nicaragua, the backbone of the continents and isthmus, running parallel and close to the Pacific shore, sinks to its lowest point, while its eastern slope is washed by that great sheet of inland sea, known as Lake Nicaragua. At this low point the divide is less than fifty feet above the level of the lake, and about one hundred and fifty feet above the mean level of the Pacific. Though the western shore of the lake is but fifteen miles from the beach of the Pacific, the lake drains through the River San Juan, into the Caribbean Sea. The lake is deep and unobstructed, and the river, already navigable for light-draught steamers throughout most of its length, requires but a little labor to deepen it.

Here, with such a vast water supply at the summit, with the lake itself as *a summit level*, nature seems indeed to have offered assistance in connecting the oceans. No great engineering difficulties in utilizing the lake are claimed, even by opponents of this route. There are no startling propositions connected with the plan.

Nature has decided its location, and it only remains for man to stake it out.

The lake and San Juan River *must* be the great part of the canal, no matter how the openings to the sea are made.

The route extends from Greytown on the Atlantic to Brito on the Pacific, a distance of 169·67 miles, divided as follows:

	Free Navigation.	*Canal in Excavation.*
Greytown to Deseado Basin,		12·37
Deseado Basin,	4·00	
From Deseado Basin to San Francisco Basin,		3·07
San Francisco and Machado Basins,	11·00	1·73
River San Juan,	64·00	
Lake Nicaragua,	56·50	
From Lake Nicaragua to Tola Basin,		8·22
Tola Basin,	5·28	
From Tola Basin to Brito,		3·50
	140·78	28·89

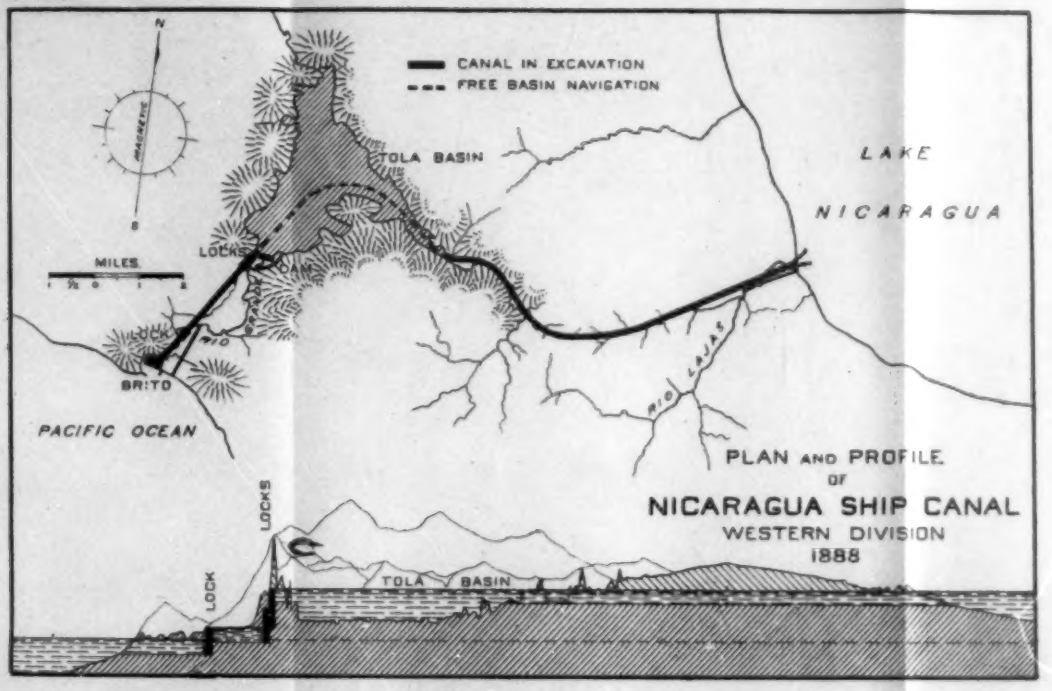
The Deseado and Tola basins are new features, brought out by the last location, as well as an increase of 2·13 miles in the length of free navigation in the San Francisco and Machado basins, or in other words, the last location has reduced the length of canal in excavation by that same distance, while the summit level has been extended from 144·8 miles to 153·8 miles.

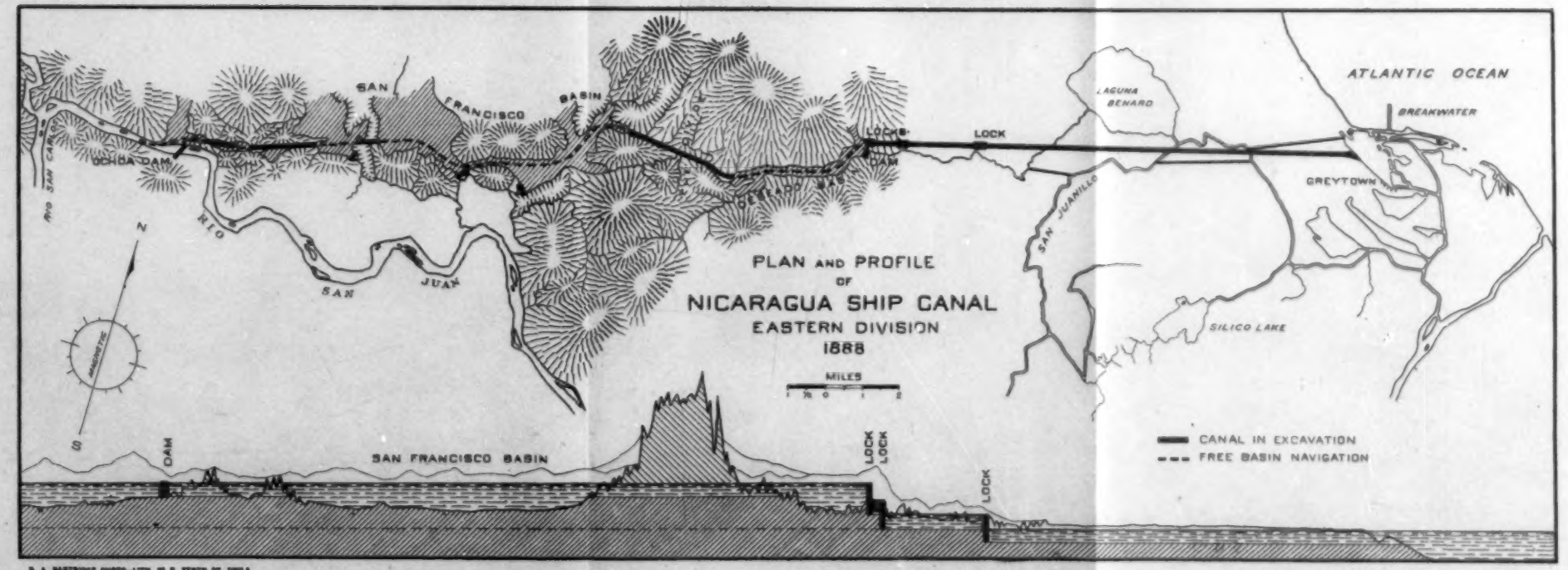
It will require some time to complete the estimate of cost on the new location, but it may be safely stated that at least ten per cent. will be gained on the total cost based on the survey of 1885, which is $64,036,197, including twenty-five per cent. for contingencies.

The accompanying plans and profiles (*Plates I, II*) explain themselves:

The principal dimensions of the canal in excavation are as follows:

Material.	Width.		Depth.
	Bottom.	Top.	
Rock,	80	80	30
Earth,	120	180	30
Sand and loose material,	120	360	30





D. A. PARTRIDGE PHOTO-LITH. 35 S. TENTH ST. PHILA.

NICARAGUA SHIP CANAL
EASTERN DIVISION
1888

The minimum radius of curvature is 2,500.

The leading engineering features, in greater detail, are: The construction of two harbors at the termini of the canal, Greytown cn the Caribbean Sea, and Brito on the Pacific Ocean; the damming of the waters of the San Juan River, for the purpose of raising and maintaining the level of Lake Nicaragua and the river at about 110 feet above mean tide; the formation of artificial basins at different levels by means of dams and embankments, and the use of locks, to pass from one level to another.

The harbors are, at present, not in good condition, but by a comparatively small expenditure of money, can be made to offer protection to vessels of the largest class. The harbor of Greytown is now closed to vessels of more than six feet draft, but the facility for reconstruction is such that in three months from the commencement of work, at the outside, a temporary opening can be made, and material safely landed by vessels of fifteen feet draft. The further improvement of Greytown harbor is only a question of the continuation of the temporary opening. It is proposed to make this opening through the sand bar which now closes the once flourishing port of Greytown, by means of a temporary jetty of brush and pile, to furnish protection to a dredge working to cut through the bar. This jetty will also give the necessary protection for the maintenance of the cut so made. The extension and strengthening by stone, of the jetty, and the continuation of the dredging, to form a permanent harbor, is simply a question of time.

The construction of a wharf at Greytown, and of a railroad from it along the line of the canal, are the connecting links in the chain of supplies. The projected final depth of the harbor is thirty feet.

The harbor of Brito will be formed by two breakwaters, giving protection from the long swell of the Pacific, and the excavation of the harbor itself from the lowlands forming the banks at the mouth of the Rio Grande.

From Greytown, the sea level is carried to the site of the first lock, which is located at the eastern end of the valley of the Deseado. Here is a lift of thirty-one feet, into the

first basin, formed by damming the lower waters of the Deseado River. Through this basin we approach rapidly locks Nos. 2 and 3, which, with their respective lifts of thirty and forty-five feet, bring us to the summit level, and clear sailing through the basins of the Deseado and San Francisco, with the divide cut between, and thence into the San Juan River, across the lake and finally through the La Flor Basin. Here, by means of a double lock, with a total fall of 85 feet, and again by the sixth and last lock, we descend to the sea level. This last lock has a variable lift, depending on the state of the tide, which on the Pacific side has a mean rise and fall of about six feet at present. The mean lift of the tidal lock is twenty-five feet. The locks are 650 x 70 x 30 feet.

As before stated, one of the principal features of the canal is the formation of large basins, by means of which the greater part of the canal is made a navigable body of water, instead of a narrow cut through the earth. As now projected, the first basin begins at the site of lock No. 1. This basin is formed by an embankment 1,100 feet long and twenty feet high, which maintains the level of the water at thirty-one feet above the sea level. A second embankment 1,400 feet long and 86 feet high, near lock No. 2 (with a lift of thirty feet), maintains the level in a small basin at sixty-one feet. A third, but smaller embankment, at lock No. 3, keeps the level at 106 feet. This is the summit level already referred to as extending from lock No. 3 to lock No. 4, a distance of 152 miles. The dam across the San Juan river at Ochoa, just east of the San Carlos, is 1,500 feet long by sixty-five high. Its purpose is to bank up the waters of the San Juan River, to a level of 106 feet or fifty-eight feet higher than at this point now. By this means a lock and a large amount of dredging is saved, and the San Juan is thus made practically navigable to Castillo, while the amount of river dredging above this point is reduced to a minimum. It will be noticed that at the dam, the level is given as 106 feet. At the lake it is 110 feet, and it is proposed to give the river a fall of four feet from the lake to Ochoa, a distance of about sixty-four miles. Again, on the

Pacific side, an embankment 2,100 feet by eighty is made across the Rio Grande. This floods the valley of the upper Rio Grande and its tributary, the Tola. Then by cutting through the low continental divide to the lake, the summit level of 110 feet is maintained to within three miles of the Pacific Ocean. The surplus flowage is provided for in all cases, by numerous waste weirs of ample capacity. Lake Nicaragua has a water shed of 8,000 square miles.

The Rio San Juan, *its only outlet*, discharges at its lowest stage, near the close of the dry season, 11,390 cubic feet per second, or 984,096,000 cubic feet per day.

The amount of water required for thirty-two double lockages is 129,479,968 cubic feet, or a little more than one-eighth of the total supply of the lake alone, to which must be added the flow of the several tributaries of the San Juan, between the lake and the sea, and the San Francisco and its tributaries.

As this supply is *from the summit*, the danger of a dry summit level, which is so serious a question with the Panama scheme, is impossible here. It is also a favorable point that the canal will be a fresh water one.

Contrary to the general opinion, the climate of Nicaragua is an equable and almost a temperate one.

No case of yellow fever has ever been known at Greytown, and Col. Squier, in his work on Nicaragua, lays stress on the fact that, while the Mexican and Central American coasts, north and south of Nicaragua, have been visited frequently by epidemics of cholera, and are subject to yellow fever more or less every year, no epidemic of any kind is known to have visited either the Pacific or Atlantic coasts of Nicaragua.

I refer to the late expedition in confirmation of this statement.

Of the forty-nine engineers and 150 men in the employ of the company, there was not a single case of serious illness, not a single case of dysentery, and but few cases of slight intermittent fever. None of these latter caused the loss of the services of those affected for more than three days.

When it is stated that the whole expedition was daily

exposed to constant wettings and dryings, often shoulders deep in marsh, and had frequently to pass the night in wet garments, the above statement would be a remarkable one for any country.

The country is capable of being developed to a great extent. It is rich in minerals, particularly gold, mines of which are now being successfully and profitably worked. Cocoa, indigo, coffee and fruit are the principal agricultural products, but the country is capable of producing a greater variety, and is particularly adapted to the growth of market garden products.

The timber is remarkable for its variety and value. Mahogany, rosewood and dye-woods are abundant, and even now large shipments of the latter are made from the Pacific Coast.

So far but one serious objection has been raised against this project, and that is that the route lies in the region of earthquakes. Upon this subject, the following extract from Mr. Menocal's report bears with much force:

"The buildings (referring to ruins left by Walker's expedition) stand to-day just as he left them, those, at least, which were allowed to remain as ruins. The houses were rebuilt, but the churches were not, and their bare, blackened walls, standing alone and devoid of any support or braces, rise to the height of, I should say, forty feet. I have examined them very carefully, and did not find a crack in them. Some of the towers were partially blown down then by powder, and look as if they were likely to tumble down at any moment. One, especially, seems threatening to fall with the wind. Yet they stand there as they have stood since 1854. These are forty-two miles from the proposed line of canal. In the town of Rivas, two and one-half miles from the canal, they have many stone houses, and about ten years ago they completed a stone church there, which has been building for thirty or forty years—one that would be a noteworthy church anywhere—and it has never received injury from earthquake shocks, nor have the stone houses about it. I had occasion to show to the United States Commissioners dams that had been built surely over 100

years ago, and are standing to-day, though not for any practical purpose; they have never been repaired, yet manifest no imperfections which can be detected by the closest examination. They were built originally for the purpose of damming up water to be used in the manufacture of indigo, and were abandoned, and have been standing there for over 100 years, perhaps."

These references show, not only that the locks and dams of the canal will not be affected by earthquakes, but that the country furnishes building materials of a superior quality.

A superior quality of lime, as evidenced by the existence to-day in an almost perfect state of preservation of indigo vats and dams over 100 years old, is obtainable at several places close to the line of the canal, and when properly manufactured there is no question but that it will prove equal, if not superior, to many cements in the market.

(*To be continued.*)

THE PARABOLIC SEMAPHORE.

BY PROF. C. HERSCHEL KOYL, Swarthmore College, Pa.

[*Read at the Stated Meeting, Wednesday, November 21, 1888.*]

JOS. M. WILSON, President, in the Chair.

PROF. KOYL:—MR. PRESIDENT AND MEMBERS OF THE INSTITUTE:

The object of a railroad signal being to show to an approaching engineman that the track is clear or the contrary, for a given distance, and the safety of trains and passengers depending upon the distinctness and the reliability of this signal, it is of the first importance that its indications should be unmistakable and itself impossible to confound with any other object along the track.

Originally the track was considered to be "clear" if no signal was displayed, while the exhibition of a disc or other board signified "danger," the appearance of the signal

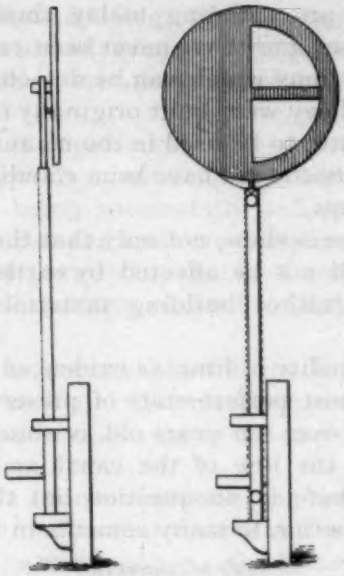


FIG. 1.—Safety. Danger.

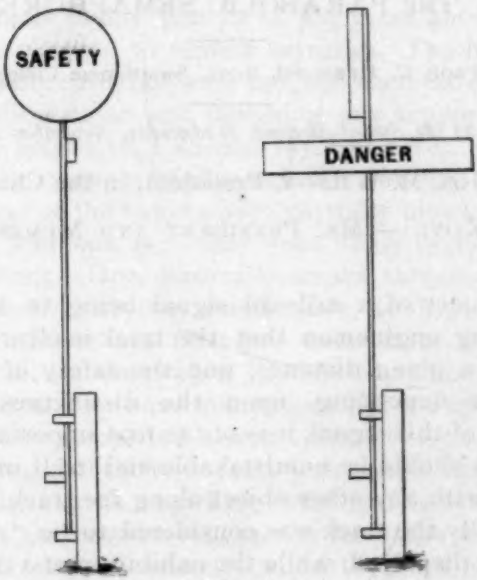


FIG. 2.

board being illustrated in *Fig. 1*. Later, a definite signal was given for "safety" as well as for "danger," *Fig. 2*, but then it sometimes happened that the signal which indicated "danger" on one road denoted "safety" on another, and such was the confusion and the desire for uniformity that when, in 1841, Mr. Gregory introduced the semaphore, *Fig. 3*, so superior to all other types of signals in its easily recognizable form and in being always visible—horizontal for

FIG. 3.

"danger" and dropped to 45° for "safety"—it began immediately to supersede all others, and is now almost the only day-light fixed signal in use on well-equipped roads.

But the difficulties attending night signals are still so numerous from the multiplicity along the track of other lights resembling those of the signal in form and color, *Fig. 4*, that the engineman can with extreme difficulty distinguish his own light, and for some years there has been a desire for a night semaphore, identical with the day signal, *Fig. 5*. Attempts have been made to illuminate the semaphore by placing a reflector along its centre, and the lamp in front; but when light from a lamp falls upon this flat surface, so much

is lost that not enough is left on the track to make the signal visible at a sufficient distance; and when detached pieces of reflector are set at different angles along the arm the apparatus becomes too cumbersome and fragile for use.

It is well known, however, that if light from the focus of a paraboloid falls upon the curve, it is from all points

FIG. 4. Railroad Signal on the Right.

reflected in lines parallel to the axis of the paraboloid, and a knowledge of this has been utilized in solving the question of a night semaphore. The arm is bent to a parabolic curve, presenting to a front view the ordinary dimensions of 5 feet 6 inches in length from the axis to the end of the blade, and 11 inches in width, and having a reflector

of silvered glass 4 inches wide along the centre from end to end. This is mounted in the ordinary casting which supports the semaphore arm and rotates about the axis in the post, which is also the axis of the paraboloid, in the focus of which the lamp is placed (*Fig. 6*).

Were the parabolic reflector of plane glass, the rays of

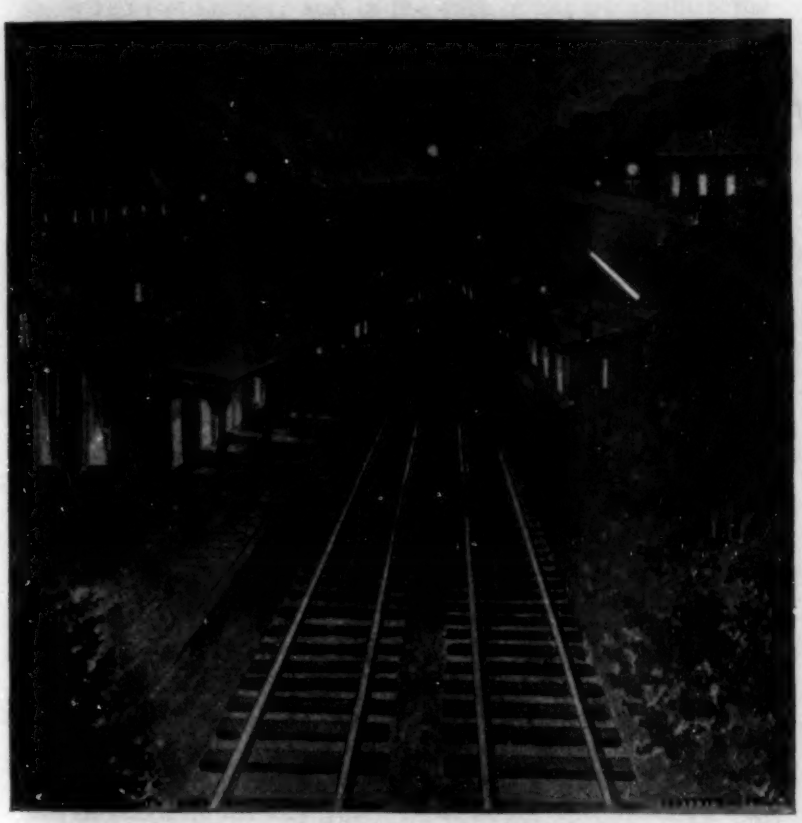


FIG. 5. Railroad Signal on the Right.

light would be almost absolutely parallel and could be seen only on a straight track; but in many cases a signal is approached around a curve, and it is necessary to diverge the light sufficiently to meet the requirements of such cases. It is accomplished by corrugating the reflector very slightly at right-angles to the directions in which the divergence is

required. For instance, to diverge the light laterally 16° from the direction of the axis requires the surface of the glass to make an angle of 8° with the parabola, and this is attained at blending intervals for both directions from the axis and for any intermediate degree of divergence by a wave surface, shown in section in *Fig.* 7, in which, if the

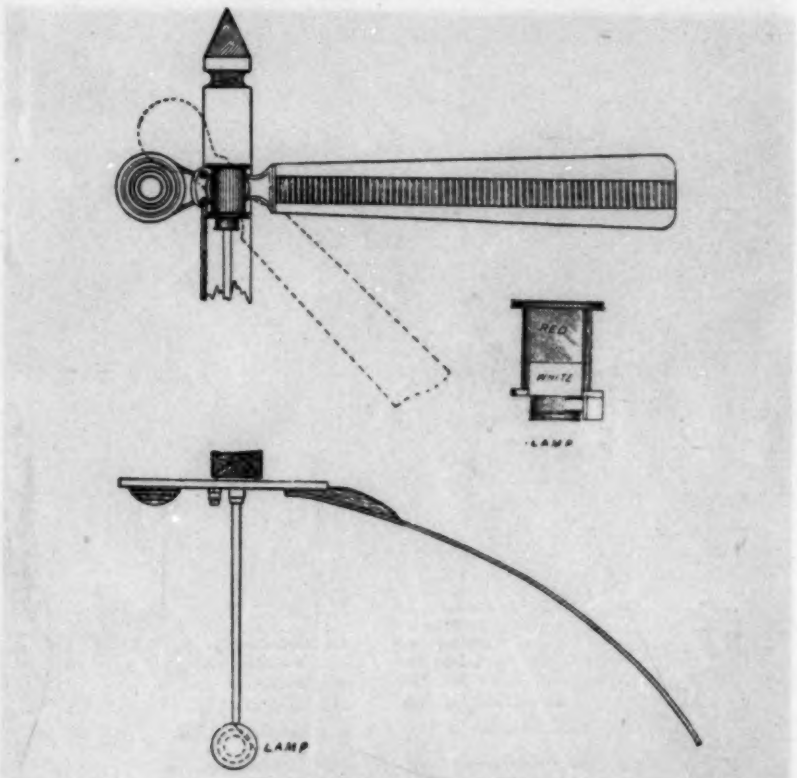


FIG. 6. Elevation and Plan.

wave-length be $\frac{3}{8}$ inch, the amplitude must be $\frac{3}{8}$ in. $\times$ *sin* 4° = approximately $\frac{1}{100}$ of an inch; and vertical divergence is gained by a wave surface at right angles to this, so that when one is superposed upon the other, divergence in all directions is the result. This makes an almost perfect position signal, giving a brilliantly-illuminated semaphore, when horizontal or when dropped.

But from the earliest days of railroading a *red* light has been the danger signal on posts, on switches, on the rear of trains, and in hand-lanterns, while a white light has always signified safety, so that the almost second nature which regards a red light as the only danger signal at night would prevent the use of any position signal which did not also show red for danger; and in the case of the parabolic semaphore, the upper half of the lamp is made red, and the lower part clear or green, so that the arm when horizontal appears red, and when dropped white or green, as the case may be.

During the day as well, the parabolic semaphore is also a color signal, for when horizontal, nothing is seen but the

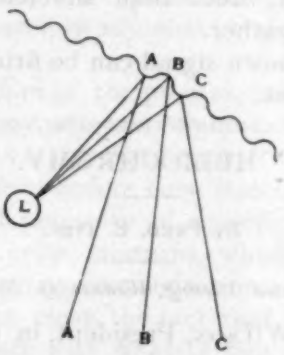


FIG. 7.

red frame and, when dropped, nothing but the glass bril liantly illuminated by the white sky.

The result is a semaphore which presents the same appearance by day and by night, which combines the qualities of a color signal with those of a position signal, which is not mistakable for any other light along the track, and the absence of which, therefore, from an accustomed place, should any accident happen to the lamp, would be immediately noticeable.

It is adapted to existing conditions because the arm is made to fit the castings at present in use and no further trouble or change is necessary than to remove the old board and put this in its place, fixing the lamp upon a

bracket in front. The reflector is of glass, with silver (not mercury) on the back, and therefore will not lose its reflecting power by exposure to the weather.

The advantages of the system may be summarized as follows:

(1) The semaphore is the standard day signal, and there is therefore no other night signal, the general introduction of which would render identical day and night systems.

(2) No other *form* of semaphore is known which will give enough light to be visible at the distance required by fast trains.

(3) No night signal would conform to well-established railroad rules which did not also show red for danger.

(4) No reflector, other than silvered glass, will stand exposure to the weather.

(5) No other known signal can be fitted to existing castings and equipment.

HELIOCHROMY.

By Fred. E. Ives.

[*Read at the Stated Meeting, Wednesday, November 21, 1888.*]

Jos. M. Wilson, President, in the Chair.

Mr. Ives: In my lecture, on "Some Recent Advances in Photography," delivered before this Institute in February last, I briefly described and illustrated a method devised by me for producing photographs in natural colors. I now have illustrations of the process, comprising a sufficient variety of subjects to more fully demonstrate its capabilities and value.

I claimed for this process that, unlike any similar process yet suggested, it was based upon a true conception of the nature of light and color vision, and was a strictly scientific method of accomplishing the object sought after—which is to produce, by an automatic process, pictures which counterfeit not only the light and shade, but also the colors of all objects which may be photographed.

I explained how some others who experimented in this direction failed, because they built upon the false theory that there are only three primary spectrum colors. I recognized the fact that there are, strictly speaking, thousands of primary spectrum colors, but also that all colors, whether simple or compound, may be counterfeited to the eye by means of three type colors, separate and mixed in different proportions. I assumed that we might counterfeit all the colors of nature in a photographic picture, by making each ray of simple color select automatically, in the operation of the picture-making process, such a type color or mixture of type colors as will counterfeit it to the eye, and showed how this can be accomplished by means of photographic plates made sensitive to all colors, and exposed through compound light filters, which are suitably adjusted by experiment upon the spectrum itself.

For the mechanism of the process, and some demonstrations, I refer to my original communication, which appeared in the JOURNAL OF THE INSTITUTE in May. I believe the problem had never before been stated with reference to the possibility and necessity of representing most of the primary colors by color mixtures, which, though not the same, produce the same color-sensation.

In order to make clear the fact that my plan of operation is in accordance with what is now recognized as the true theory of the nature of light and color-sensation, I make the following quotations from a recently published text-book on *Color*, by A. H. Church, M.A., London:

"Young's theory does not assume the existence of three primary colors, but of three primary color-*sensations;* a very important distinction.

"Every ray of differing refrangibility in the visible part of the spectrum is in one sense a primary color, for it is simple, and excites a definite sensation. But there are many reasons, mainly connected with the structure and functions of the eye, which have led to the selection of certain colored lights—generally three in number—as yielding primary color-*sensations.* This primariness is then not objective, but subjective in respect of human vision.

"Young's theory of color-perception amounts essentially to this, that in each elementary part of the retina of the eye there is, at least, one set of three different nerve fibrils, each of the three fibrils of a set being especially adapted for the production of its own specific color-sensation, yet in a less degree of the two others. Thus the receptive structure of the retina as a whole may be said to consist of an immense number of nerve fibrils of three orders; what we may call red fibrils being particularly acted upon by such long light waves as those in the red, but being also stimulated in a minor degree by the shorter waves in the green, and still less by those in the blue; the green fibrils will respond most actively to green waves, and in some measure, also, to red and to blue waves; while the blue fibrils will be most excited by the blue rays, though not uninfluenced by green and even by red rays.* It follows that when all three kinds of nerve fibrils are equally and simultaneously affected, the complex sensation of white light alone is produced.

"Colored lights may be, and often are, compound, sometimes consisting of two, and often of many more differently-colored elements, although the eye recognizes but a single color in the complex ray. A striking instance is afforded by yellow. There is an elementary yellow in the solar spectrum lying on the green or more refrangible side of the line *D*. By no contrivance can we optically decompose this spectral yellow, to which belongs a definite wave-length. But there are many compound yellow lights—lights which give us, as the sum of the simultaneous visual impression of their several components, a sensation of yellow not to be distinguished by the brain from the simple yellow of the spectrum. Such a compound yellow may be formed by throwing on the same portion of a screen a part of the red light and a part of the green light of a pure spectrum.

* "Helmholtz remarks, that the choice of these particular colors is somewhat arbitrary, and that any three could be chosen, which, when mixed together, would furnish white light. If, however, the end and middle colors of the spectrum (red, violet and green) are not selected, then one of the three must have two maxima, one in the red and the other in the violet; which is a more complicated, but not an impossible supposition."

Similarly there is a pure and simple blue in the spectrum, but a blue indistinguishable from this in hue may be obtained by mingling green and violet light."

Now, although I originally worked out my process on the simple plan of making each primary ray of spectrum color select from and combine three pigment colors to counterfeit it, it becomes evident that in accomplishing this I might have produced one negative by the action of solar rays nearly in proportion as they excite the "red nerve fibrils" of the eye, another in proportion as they excite the "green fibrils," and another in proportion as they excite the "blue fibrils." I did not do this at once, but after experimenting with several sets of reproduction pigments, adjusting color-screens so that I could make the process counterfeit the spectrum with either set of pigments, I finally adopted reproduction colors which call for negatives of the spectrum showing curves of intensity approximating to the curves in Maxwell's diagram, illustrating the action of the spectrum upon the different sets of nerve fibrils. These reproduction colors are certain shades of red, green and blue light, or their complementary colors in pigments, which approximate to Prussian blue, magenta red and aniline yellow, the first two of so light a shade that it is necesary to superimpose one upon the other to obtain a full violet blue, the blue upon the yellow to obtain green, and the magenta upon yellow to obtain red.

When I made my first communication upon the subject, I assumed, with Helmholtz, that there might be some latitude in the selection of type (reproduction) colors, and therefore did not commit myself to the use of any particular ones, but merely showed how I would produce at will negatives of the spectrum having any curves of intensity that might be required in order to secure the proper distribution of such colors or pigments as were selected. The adoption of reproduction colors corresponding to what are now recognized to be the primary color-sensations, has made it possible for me to state more definitely my mode of procedure, as above.

What I claim as new and original in my method is (1) the

production of heliochromic negatives by exposing color-sensitive plates through compound color-screens, which have been adjusted to secure negatives showing curves of intensity which bear a certain definite relation to the colors employed to produce the heliochromic pictures; and (2) the production of heliochromic negatives by a procedure calculated to yield negatives of the spectrum showing curves of intensity which probably correspond to the action of the spectrum upon the sets of nerve fibrils.

Admitting the theoretical soundness of my mode of procedure, which I believe I have fairly demonstrated, there remains only the question of practicability and commercial value to be considered. The process is practicable, if the same operations, repeated in the same manner, can be relied upon to produce pictures which counterfeit the light and shade and color of all objects. Three subjects, which I shall show to-night, a delicate oil-painting, a brilliant Prang chromo and a beautiful sea-shell, were made with the same light, same camera, same preparation of sensitive plates, same set of color screens, same relative exposures and same development. They show a very great variety of colors, mostly compound in the painting and chromo, but pure spectrum colors in the sea-shell; yet the colors of all are alike faithfully counterfeited to the eye. Although there should be no question of the fact, I will here state that these finished results have been obtained without any retouching or artificial manipulation whatever.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, December 18, 1888.*]

HALL OF THE FRANKLIN INSTITUTE.

PHILADELPHIA, December 18, 1888.

Mr. J. H. EASTWICK, President, in the Chair.

Members present: Dr. L. B. Hall, Dr. S. C. Hooker, Dr. H. W. Jayne, Messrs. Luthy, Macfarlane, Chase, Bower, Pemberton, Matos and Palmer.

The bills for printing were approved, and ordered to be paid.

Mr. John G. Bullock's resignation as a member of the Section was accepted.

Mr. Philip E. Clarkson, of Quaker City Dye Works, and Mr. Jacob Lichenheim, 1614 North Tenth Street, Philadelphia, were elected full members of the Section.

The following gentlemen were nominated for membership in the Section: Mr. F. C. Lewin, 1011 Spruce Street, Philadelphia; Mr. C. V. Petraeus, 231 South Front Street, Philadelphia; Mr. R. E. Fisher, 2239 St. Alban's Place, Philadelphia; Dr. Wm. H. Greene, 204 North Thirty-sixth Street, Philadelphia; Dr. Geo. A. Koenig, University of Pennsylvania, Philadelphia; Mr. Henry C. Lea, 2000 Walnut Street, Philadelphia; Prof. Henry Morton, Stevens Institute, Hoboken, N. J.

The following gentlemen were elected officers of the Section for the year 1889:

President, Mr. H. Pemberton, Jr.
Vice Presidents, Dr. S. C. Hooker, Mr. T. C. Palmer.
Secretary, Dr. Wm. C. Day.
Treasurer, Dr. H. W. Jayne.
Conservator, Dr. Wm. H. Wahl.

Mr. H. Pemberton, Jr., presented a communication from Dr. Wm. H. Wahl, Secretary of the INSTITUTE, concerning the publishing of papers read before the Section, in the JOURNAL OF THE INSTITUTE, simultaneously with other journals to be selected by the Section.

The President appointed as a committee to confer with Dr. Wahl on this matter, Mr. H. Pemberton, Jr., Dr. S. C. Hooker.

The following were appointed a committee to revise the membership list, and re-arrange the By-Laws of the Section: Mr. T. C. Palmer, Dr. H. W. Jayne, Mr. R. L. Chase.

Mr. O. Luthy exhibited a piece of the mineral eudialyte, from Greenland. This species is a prominent source of zirconium. Mr. Luthy stated that it had lately been found in large quantities in the above country, near the cryolite locality. Twenty tons had been shipped to Europe at one time. Dr. Jayne stated that this material is largely imported into this country from Sweden, being used in the manufacture of the films for the Welsbach gas lights.

Mr. Chase remarked that there has been much difficulty in getting a film for these lamps that will be durable. Cases have been known where these films were broken by the slight jar caused on a floor above by falling boxes.

Dr. Hooker remarked that the burette, exhibited by him in October, was thought at the time to be new. He had since had his attention called to the figure of a burette almost identical with this.

Dr. Hooker showed several samples of sugar said to have been refined by the aid of electricity. These samples are different in appearance from any sugars heretofore in the market, but Dr. Hooker was of the opinion that much nonsense had been published by the non-scientific press on the subject of sugar-making by electricity; that it would be very easy to give granulated sugar this same appearance by caking and passing through a sieve. Mr. Luthy had also investigated the matter, and had concluded that this so-called electrically-refined sugar is only ordinary sugar specially prepared.

Mr. Macfarlane showed a copy of the souvenir published by Meister, Lucius & Bruening, on their twenty-fifth anniversary, July 2, 1888. This souvenir contains statistics of the growth and present dimensions of the great color works of this house, bird's-eye views of the buildings, maps of the enclosures, etc.; also a very beautiful spectrum of colors (all artificial) dyed on yarn.

Dr. Hooker showed a sample of saccharine, and remarked that many tests had been proposed for its detection, but that the most reliable one was based on the following principle:

The suspected substance is treated with ether, the extract evaporated and the residue fused with caustic potash, when if saccharine is present, salicylic acid is formed, and may be detected by the violet color formed with ferric chloride.

Dr. Jayne mentioned the fact that the use of saccharine had been prohibited in France for certain purposes, for revenue reasons. The same is true in England. Dr. Hooker stated that the evidence seemed to show that saccharine impairs the digestive process. Dr. Hall thought that this was doubtful, German authorities of high rank altogether dissenting.

Adjourned. T. C. PALMER, *Secretary.*

(Subject to Revision.)

ON THE DETECTION OF FAHLBERG'S SACCHARINE.

BY SAMUEL C. HOOKER, Ph. D.

[*To be read January 15, 1889.*]

A test has been recently described by E. Börnstein * for the detection of saccharine, based upon the supposed formation of a sulpho-phtaleïn. Saccharine is heated with a slight excess of resorcine and a few drops of concentrated sulphuric acid; on the addition of water a solution is obtained which fluoresces strongly when rendered alkaline.

I wish to point out that this test is rendered valueless by an observation I made about a year ago. Resorcine, when treated with sulphuric acid *alone*, gives apparently precisely the same reaction as that which Börnstein describes as characteristic of saccharine.

The reaction has unfortunately been already used in several instances which have come under my notice, and the presence of saccharine inferred in cases in which it was probably altogether absent.

It has long been known that resorcine, when heated with zinc chloride, also gives rise to products which fluoresce strongly.

A RAPID COLORIMETRIC METHOD FOR THE ESTIMATION OF NITRATES IN NATURAL WATERS.

BY SAMUEL C. HOOKER, Ph. D.

[*Read October 21, 1888.*]

It was long ago observed by Graebe and Glaser,* that the addition of oxidizing agents, in small quantity, to carbazol dissolved in concentrated sulphuric acid, gave rise to an intensely green solution. Up to the present time no useful application has been made of this reaction.

* *Berichte*, **21**, 488, R.

In devising a process for the rapid estimation of nitrates in the minute quantities in which they occur in natural waters, I have taken advantage of this property of carbazol. I have ascertained that under certain conditions, water containing as little as two parts of nitric acid per million gives a distinct reaction with the sulphuric-acid solution of carbazol; and that within certain limits the intensity of the color produced may be taken as the measure of the nitric acid present.

The estimation briefly described, omitting the necessary precautions, is conducted as follows: A measured quantity of the water, 2 cc. or less according to circumstances, is mixed with about 4 cc. of concentrated sulphuric acid, and when this has cooled a small quantity of sulphuric acid containing carbazol in solution is added. The green color produced is compared with that given by standard solutions of potassic nitrate, under precisely similar conditions, until the color is closely matched. The estimation is very rapidly effected, and provided the water contains as much nitric acid as two parts per million, as is very often the case, it need not be concentrated by evaporation.

The details of this process, together with the precautions to be taken in the presence of chlorides, nitrites, etc., will be described shortly in a paper giving the results of analyses made with the object of testing the delicacy of the method.

In conclusion, I would suggest the possibility that other compounds, diphenylamine or brucine, for instance, may prove as serviceable as carbazol for the purpose here described.

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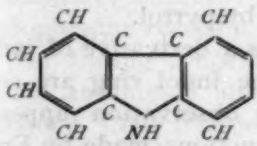
* *Ann.*, **163**, 347.

ON THE RELATIONS EXISTING BETWEEN CARBAZOL AND PYRROL.

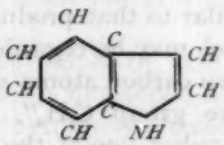
BY SAMUEL C. HOOKER, Ph. D.

[*To be read January 15, 1889.*]

The theoretical relation existing between carbazol, indol and pyrrol is well shown by comparing their formulæ as follows:



Carbazol.



Indol.

Pyrrol.

The analogy existing between indol and pyrrol has received important experimental demonstration from the researches of v. Baeyer, E. Fischer,* and Ciamician,† but up to the present time no material evidence has been accumulated to show that a similar relation exists between carbazol and pyrrol. The formation of carbazol from thio-diphenylamine‡ by the action of copper furnishes some proof in support of the formula given above; but as this is the only reaction clearly tending to show that carbazol is a di-ortho derivative of diphenyl, and, therefore, that it contains the pyrrol ring, further evidence in the same direction appears desirable.

In making the experiments which led up to the facts here recorded, I hoped to find points of resemblance between carbazol and pyrrol for which the >NH group alone, independent of the pyrrol ring, would not account, and thus to confirm indirectly the above formula of carbazol.

Runge, the discoverer of pyrrol, observed that its vapor in contact with pine moistened with hydrochloric acid,

* *Ber. d. chem. Ges.*, **19**, 2,988.

† *Ibid.*, **19**, 3,028.

‡ *Ibid.*, **20**, 232.

colored the wood intensely red. Von Baeyer subsequently described this reaction as being very characteristic of indol. It is interesting, therefore, to find that carbazol reacts similarly, though not so readily. In order to observe the reaction, soak the wood—an ordinary match-stem answers admirably—for a second or two in a hot alcoholic or acetic-acid solution of carbazol, and then thrust it into the neck of a bottle containing concentrated hydrochloric acid, so as thoroughly to expose it to the action of the gas without bringing it in contact with the acid solution. The red color soon develops, and slowly increases in intensity. The shade is precisely similar to that produced by pyrrol.

Since carbazol may be regarded as a derivative of indol in which the two carbon atoms of the indol ring are connected with the group C_4H_4'', this observation appears directly to contradict one of the deductions made by Emil Fischer* in the course of his study of indol derivatives. "The fir-wood reaction," he says, "no longer occurs when both the carbon atoms of the indol ring are connected with alkyls."

It seemed necessary, therefore, to confirm my results by substituting synthetical carbazol for that extracted from coal tar, with which I first obtained the reaction. In spite of careful purification, it is conceivable that the coal-tar carbazol might still retain traces of foreign substances capable of imparting to it the power of coloring the wood.

Through the kindness of Dr. A. Goske in forwarding to me a sample of carbazol recently obtained by him† by the action of copper on thio-diphenylamine, I have been able to confirm the results of previous experiments in a satisfactory manner.

It seems possible therefore that the di-alkyl derivatives of indol which do not, according to Emil Fischer, give the fir-wood reaction when the test is made in the usual way, may do so if the conditions of the experiment are somewhat varied.

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* *Ber. d. chem. Ges.*, **19**, 1,570.

† *Ibid.*, **20**, 232.

CARBAZOL AND ISATIN.

The behavior of thiophene (and furfuran) in forming coloring matters with isatin and ortho-diketones apparently similar to those of pyrrol, makes it probable that in such reactions the >NH group of pyrrol takes no part. Consequently, in the case of carbazol, as all the hydrogen atoms of the pyrrol ring, excepting that of the imide group, are already substituted, it is not to be expected that any similar coloring matters can be formed. For this reason I was surprised to find that the behavior of carbazol and isatin in the presence of sulphuric acid is such as to strongly suggest the indophenine reaction.

On adding concentrated sulphuric acid to carbazol and isatin, an intense blue color is developed as the substances dissolve. The reaction is extremely characteristic and can be used as a delicate test for the recognition of carbazol. The blue color of the solution does not appear to be affected by slightly warming, and even after standing some hours its intensity had not materially diminished or its color otherwise changed. Water precipitates an indigo-blue substance which very rapidly becomes lighter in color. In order to avoid this change, attempts were made to extract the blue coloring matter from the acid solution without the addition of water, by agitation with various solvents. These experiments proved unsuccessful, and the further study of the compound was abandoned.

Although the above is very like the indophenine reaction and its apparently analogous reaction in the case of pyrrol, I am inclined to believe, for considerations already mentioned, that the similarity is apparent only and not real. Diphenylamine gives no reaction with isatin under the same circumstances.

Since diphenylene-oxide and diphenylene-sulphide are probably related to furfuran and thiophene, respectively, in the same way as carbazol is to pyrrol, it seemed of importance to ascertain whether these substances also behaved similarly with isatin. I was unable to obtain any reaction with diphenylene-oxide, and consequently it is probable that diphenylene-sulphide also will be found indifferent.

CARBAZOL AND QUINONE.

The compounds produced from pyrrol and benzoquinone have no corresponding members in the thiophene series, and would appear to be directly or indirectly dependent upon the >NH group for their existence; it therefore seemed possible that carbazol and benzoquinone might react with the formation of similar compounds.

If a small quantity of sulphuric acid, diluted with one or two volumes of acetic acid, is added drop by drop to an acetic-acid solution of carbazol and benzoquinone, an intense carmine red solution is produced, which passes into a reddish-violet as the quantity of sulphuric acid is increased. Water precipitates from this solution a substance of the same color, which dissolves very readily in ether, chloroform and alcohol.

On the addition of crystals of quinone to carbazol dissolved in concentrated sulphuric acid, an intense green color is imparted to the solution. Hence, according to the strength of the acid used, a reddish-violet or a green solution is obtained.

Similarly Victor Meyer and O. Stadler* haves hown that benzoquinone reacts with pyrrol in two distinct ways. If aqueous solutions of the two are mixed, a violet coloring matter is produced, whereas in the presence of dilute sulphuric acid a green precipitate is formed. For purposes of comparison I repeated V. Meyer and Stadler's experiments. The violet coloring matter obtained dissolved in ether to a solution very similar in shade to that of the ethereal solution of the coloring matter from carbazol.

Before concluding that the formation of these compounds is in any way connected with the existence of the pyrrol ring, it seemed necessary to study the action of diphenylamine under similar circumstances. Sulphuric acid added to diphenylamine and quinone dissolved in acetic acid immediately colors the solution blue; on adding water, a violet substance is precipitated.

These reactions recall the coloring matters obtained by

* *Ber. d. chem. Ges.*, **17**, 1,035.

P. Greiff* by heating chloranil or quinone with methyldiphenylamine and other amines with or without the addition of zinc chloride. The similarity existing between the method of formation and the shade of Greiff's coloring matters and the violet compounds obtained as above described from pyrrol, carbazol and diphenylamine, renders it extremely probable that in both cases the coloring matters are perfectly analogous, and that their formation in the case of pyrrol and carbazol depends upon the amine character of these substances, and not upon the presence of the pyrrol ring. This view, which could not, unfortunately, be substantiated by analysis, owing to the great instability of the pyrrol compound, receives support from the fact already alluded to that thiophene gives no coloring matters with benzoquinone.

With reference to the green solution formed on adding quinone to carbazol dissolved in sulphuric acid, it seems probable that in this case quinone plays the part of an oxidizing agent only, for the same green-colored solution is produced, as is well known, by the addition of oxidizing agents generally under similar circumstances. It occurred to me, therefore, as not unlikely that quinone acts merely as an oxidizing agent also, when in contact with pyrrol in acid solution, especially as V. Meyer and Stadler extracted hydroquinone in considerable quantities from the mother-liquor after the green compound had been filtered off. Confirmation of this view was obtained by reference to Anderson's† description of the properties of pyrrol. He states that ferric chloride causes a dilute hydrochloric-acid solution of pyrrol to turn first *green* and then black. He adds that platinic chloride and potassic bichromate produce a black precipitate with the same solution.

A few experiments soon proved that not only ferric chloride, but potassic chromate or bichromate, platinic chloride, potassic ferricyanide, and even potassic nitrite under certain circumstances, all give, when added in small quantity

* *Ber. de chem. Ges.*, **12**, 1,610.

† *Ann. Chem.* (Liebig), **105**, 354.

to a dilute sulphuric-acid solution of pyrrol, a green substance which passes more or less rapidly, according to the oxidizing agent used and the acidity and degrees of concentration of the solutions employed, into the black compound observed by Anderson. With tolerably concentrated solutions of the oxidizing agents, the transition is so rapid that the green color can be scarcely observed, even when the sharpest lookout for it is maintained throughout the experiment.

With a dilute solution of potassic chromate, the formation of the green substance may be readily seen, and the reaction compared with that of quinone. As it is not easy, however, to obtain the reaction at its best without a number of trials, I prefer to give the exact strength of the solutions which I found to give good results. Eight drops of pyrrol are dissolved in 10 cc. of water to which eight drops of sulphuric acid have been added. When this is mixed with an 0·1 per cent. solution of potassic chromate in equal volumes, the green color is almost immediately developed, and rapidly increases in intensity until the solution becomes perfectly opaque. At this stage three or four volumes of water are added. The diluted solution is green in color, and slowly deposits a dark green or black precipitate.

A very dilute aqueous solution of quinone behaves almost precisely similarly with the above solution of pyrrol, but the precipitate formed is at first much greener than when potassic chromate is the oxidizing agent used. It gradually darkens, however, and after some hours becomes almost black. If the green precipitate from quinone is washed with an 0·05 per cent. solution of potassic chromate, it is very rapidly blackened.

From these experiments it would appear extremely probable, therefore, that quinone does not condense with pyrrol in acid solution, but merely acts like other oxidizing agents.

The formation of green substances like the above is not confined to the action of oxidizing agents on carbazol and pyrrol. It has long been known that nitrous acid and other oxidizing agents added in small quantity to diphenylamine

dissolved in sulphuric acid, produce an intense blue solution from which water precipitates a green compound; this, like the corresponding compounds from carbazol and pyrrol, is insoluble in ether.

PYRROL AND PICRIC ACID.

The behavior of indol and carbazol in combining with picric acid suggested the idea that probably pyrrol would form a similar compound. On adding picric acid to an excess of pyrrol, a red color is at once developed; on warming, the picric acid is dissolved, and the solution, when cold, deposits beautiful red needles. Similarly, if picric acid and an excess of pyrrol are dissolved in alcohol, long red needles, half or three-quarters of an inch in length, can be readily obtained as the solution is allowed to evaporate. The compound is very unstable, and commences to decompose in the air as soon as the crystals are dry. Its fusing point is about 71°. Since the basic properties of pyrrol are very weak, and no well-defined salts have been obtained with acids generally, the above described compound must be considered as analogous to the picric acid compounds of the hydrocarbons. The relation of pyrrol to benzol, so often dwelt upon by Victor Meyer, is thus once again emphasized. Phenyl-pyrrol also forms an unstable compound with picric acid. The compounds of pyrrol and its derivatives with picric acid will be further studied, and an attempt will be made to analyze them.

[COMMUNICATION.]

FOR SEALING OF VOLATILE LIQUIDS IN GLASS TUBES.

GENTLEMEN: The following communication on "The Sealing of Volatile Liquids in Glass Tubes," may be found of general interest. In order that glass tubes containing very volatile liquids may be properly sealed, the temperature of the tubes and their contents must be so lowered that the vapor tension of the liquid is not greater than the

atmospheric pressure. This is accomplished by immersing the tube in a cooling mixture to within a short distance of the point at which it is to be sealed. A tube containing liquid sulphur dioxide may thus be sealed while it is surrounded by a mixture of ice and salt.

When the required temperature is below that of the ordinary freezing mixtures, advantage must be taken of the evaporation of liquid carbon dioxide or nitrous oxide at low pressures, and by care in manipulation it is then not difficult to seal tubes that are nearly filled with such volatile liquids as the two just named.

The tubes intended to contain such specimens, and which may be used to illustrate the phenomena of the critical condition and the precipitation of saturated vapors, must be made ready for sealing several days before they are to be filled, and carefully annealed in order that the glass may be prepared for the considerable pressure which it must sustain. Ordinary stout tubing with walls about two millimetres thick, and of five to seven millimetres internal diameter, may be employed. The piece selected is prepared by contracting the diameter to about two millimetres near one end, closing this end and blowing it into a funnel a little larger than necessary to hold all the liquid required to fill the tube. The other end of the tube is then sealed at the desired distance from the contraction—twenty centimetres is a convenient length. When the tubes have recovered from the effects of the heating, or immediately after they have been annealed in an oven, they are ready for filling and sealing.

The apparatus required for cooling the tubes during the operation is easily constructed, as shown in the accompanying diagram. A stout test tube, *A*, about twenty-five millimetres diameter, and of such length as is required by the tube to be sealed, passes through a flat cork in the mouth of a strong bottle, *B*, containing some pumice stone moistened with sulphuric acid. This test tube is half or two-thirds filled with liquid nitrogen monoxide or carbon dioxide, and about one-fourth as much ether is cautiously added. To the test tube is adapted a rubber stopper carrying the

tube *C* to be filled, the contraction at which it is to be sealed being about one centimetre above the level of the stopper, and a bent tube, *D*, the external end of which is connected with an aspirator.

The almost capillary extremity of a bent tube, *E*, is then passed through the contraction below the funnel, and through this the air is rapidly sucked from the tube as the liquid nitrogen monoxide is poured into the funnel. There must be sufficient space between the capillary tube and the walls of the contraction to allow the free descent of the liquid. When a sufficient quantity of liquid has been introduced, it is necessary to wait until the gauge of the aspirator

shows a constant pressure; the tube is then cut off at the contraction and sealed by directing on it the flame of a movable blast lamp. The tube *D* is then disconnected with the aspirator, and the sealed tube with the rubber stopper is carefully removed and placed vertically where its possible explosion on warming will do no harm. Pieces of bamboo cane, so cut that the joints form the bottom, make convenient receptacles for the tubes while they take the temperature of the room.

After the tubes have assumed the ordinary temperature, they should be gradually warmed to the highest degree to which they will probably be exposed, in order that there may be no risk in handling them.

If a mixture of nitrous oxide and ether be used for cooling, there should be no flame in the neighborhood of the recipient while it is open.

If the specimen be intended to illustrate the critical phenomena, the tube should be at least three-fourths filled with liquid before sealing. If it be designated to show the formation of a cloud and the precipitation of liquid drops, it should not be more than one-third filled.

I am indebted to Mr. Thos. R. Harrison for valuable assistance in preparing several tubes of nitrogen monoxide in the manner described.

Very truly,

WM. H. GREENE.

CENTRAL HIGH SCHOOL,
PHILADELPHIA, December 1, 1888.

ABSTRACTS.

REDUCTION PRODUCTS OF HÆMATOXYLIN (J. Hegler. *Moniteur Scientifique* from *Jour. of Soc. of Dyers and Colorists*, **4**, 129). Many attempts have been made to reduce hæmatoxylin, without satisfactory results.

Fr. Reim found that this coloring matter was not affected by sodium amalgam or zinc and sulphuric acid. On heating it with zinc powder, he obtained a crystallizable body, suspended in an oily liquid, but in too small a quantity to analyze it. Heavy gases were evolved at the same time, arising from the decomposition products, which could not be condensed.

E. Erdmann and G. Schultz have obtained, by heating hæmatoxylin in closed tubes with hydriodic acid, a mixture of hydrocarbons, which are partly volatile in steam and partly soluble in benzene.

C. Dralle, in confirmation of Fr. Reim's results, has detected the presence of carbonic acid and resorcin in the products of distillation.

The author's attempt to reduce hæmatoxylin with zinc powder also gave too small amounts of product to analyze.

The author tried the acetyl derivative obtained by the action of acetyl chloride. One part of the acetyl derivative of hæmatoxylin was gradually heated with thirty to forty parts of zinc powder in a slender tube under the air pump. The distillation product obtained in this manner consisted of resorcin in aqueous solution and a yellow oil, with a characteristic smell.

The author tried to separate the different products by fractional distillation.

The body, which passes over above 300° C., is solid, yellow, soluble in alcohol, ether, glacial acetic acid and benzene.

From these solutions it crystallizes in small yellow needles, grouped in stars, which fuse at 80°. This body forms a compound with picric acid which decomposes at 105°.

Three analyses gave the following results:

	Found.			*Calculated for.*		
	I.	II.	III.	$C_{15}H_{10}$	$C_{15}H_{14}$	$C_{16}H_{16}$
C.	90·82	90·58	90·71	91·82	92·78	91·42
H.	7·99	7·74	7·88	8·17	7·21	8·57

Owing to the small amount of substance obtained, it was not possible to have the hydrocarbon free from a small amount of a substance containing oxygen.

The vapor density determined by V. Meyer's method in sulphur vapor, together with the analysis, indicate the body to be a hydrocarbon $C_{15}H_{10}$, which is probably a homologue of diphenyl.

Vapor density—

Found.	*Calculated for.*		
	$C_{15}H_{10}$	$C_{15}H_{14}$	$C_{16}H_{16}$
6·88 and 6·72	6·79	6·72	7·27

The fraction between 200° and 300° passes over mostly at 250°–260°. It is a yellowish oil, with a strong smell, which turns brown in the desiccator over sulphuric acid. It is insoluble in alkalies, which is contrary to the character of a phenol.

On analysis it gave the numbers—

	I.	II.
C =	88·24	87·93
H =	8·04	8·20

Its vapor density in sulphur was 5·59.

The portion passing over between 100° and 200° is a volatile liquid, with a penetrating odor, and is insoluble in alkalies. Unfortunately the author had too little substance to determine its vapor density.

On analysis the results indicated that it had the formula $C_{10}H_{14}O$.

	Found.		*Calculated for.*
	I.	II.	$C_{10}H_{14}O$
C.	80·79	79·79	80·00
H.	8·94	8·92	9·33

H. T.

On the Detection and Estimation of Magenta in Orchil and Cudbear. By Christopher Rawson (*Journal of Soc. of Dyers and Colorists*, **4**, 68).—The author has found such difficulties in the use of previously-published processes, that he suggests the following based upon the complete precipitation of the coloring matter of orchil or cudbear in an aqueous and alcoholic solution by acetate of lead, followed by an excess of ammonia. Magenta base under the same conditions remains in solution. From one to two grains of cudbear (or an equivalent amount of orchil liquor) are boiled with 50 cc. of alcohol, and afterwards diluted with 100 cc. of water; 15 to 20 cc. of a strong solution of basic acetate of lead (sp. gr. 1·25) are then added, followed after stirring by a similar quantity of strong ammonia. The mixture is filtered, and if the amount of magenta present is to be *estimated*, the precipitate is washed with a solution containing one part of ammonia, five parts of alcohol and ten parts of water; otherwise the washing may be

neglected. With pure cudbear, the filtrate is quite colorless; if magenta be present, it is either colorless or pink, according to the amount of ammonia present in the solution. The liquid is then acidulated with acetic acid, when the presence or absence of magenta is at once made apparent; in the case of pure cudbear or orchil, the solution remains colorless; whereas, if a salt of rosaniline be present, the well-known color of magenta is immediately developed. By means of this method one part of magenta in 100,000 of cudbear can be detected with certainty.

For determining the *amount* of magenta present the author suggests a calorimetric method, in which the filtrate or an aliquot portion of it is compared with a standard solution of magenta.

The method is also applicable to the detection of methyl violet and safranine. The base of the latter is much more soluble in ammonia than those of methyl violet and magenta.

The three coloring matters are distinguished from one another on the addition of acetic acid to the ammoniacal filtrate, the solution becomes of a bluish violet tint, if methyl violet be present. Under the same conditions, solutions of safranine and magenta are pink or bluish red. Strong ammonia decolorizes methyl violet and magenta, whereas it produces little or no effect upon a solution of safranine. Strong hydrochloric acid added to a solution of safranine, changes the color to a blue; solutions of magenta and methyl violet become, with the same reagent, of a pale yellow color.

The azo or oxy-azo dyes, as rocellin, orchil red, etc., when present in cudbear, may usually be detected by sprinkling a little of the sample on the surface of concentrated sulphuric acid, with the formation of a characteristic colored streak, which may be either green, blue or violet. To detect other adulterations, or in cases of doubt, one should resort to dye tests. H. T.

On the Preparation of Anhydrous Magnesium Chloride.—Walther Hempel (*Berl. Ber.*, **21**, 897). Anhydrous magnesium chloride is ordinarily made by the addition of ammonium chloride to the solution of the salt and the decomposition of the ammonio-magnesium chloride so formed by heating to about 460°. The author has found that the solution of magnesium chloride may be evaporated without decomposition and formation of basic salt, provided the operation be performed in an atmosphere of hydrochloric acid. The addition of ammonium chloride is unnecessary, and there is a great economy of heat. W. H. G.

BOOK NOTICES.

Soaps and Candles. By James Cameron, F.I.C. Philadelphia: P. Blakiston, Son & Co. 1888. Price, $2.25.

Dr. Johnson once remarked to a certain Mr. Cambridge: "Knowledge is of two kinds. We know a subject ourselves, or we know where we can find information upon it. When we inquire into any subject, the first thing we have to do is to know what books have treated of it." This remark

applies with much more force to-day than it did a century ago when it was uttered. But to no branches of knowledge is it so applicable as it is to those that are of a scientific nature. Indeed, it is becoming quite a serious problem to know how to separate and disentangle any desired information from the huge mass of facts contained in the volumes of the many scientific journals now published. The editors of these journals recognize this difficulty, and, accordingly, give not only an index of each number and of each volume, but also publish at intervals of a few years an index of the series of volumes that has appeared in the interim. This is true, for instance, in the case of *Dingler's Journal*, of *Silliman's Journal*, and of others that might be mentioned. The preparation of such indexes is tedious and expensive, and would, therefore, be likely to be shirked were it not that the necessities of the case actually force the editors to take the step. They have been obliged to do so with the journals, not only because the latter contain an extraordinary variety of information, but also for another reason. These journals are to the scientific man what the daily newspapers are to the general public. They present the very latest information; they give it in its discursive and formative stages; they contain an abridgment, at least, of all the new ideas propagated, of all the inventions made, of all the patents issued that come within their respective departments of science. They are away and far ahead of any other vehicle of knowledge, and frequently lead the encyclopædias, treatises, manuals and text-books by a good decade at least. It is not too much to say that many of the facts and discussions appearing in the journals and technical papers of to-day will not be embodied in the text-books until the beginning of the next century.

The important position, therefore, held by this form of scientific literature, forces the editors to publish frequent and copious indexes, covering back volumes, as already described. But there are very few writers of *books*, who follow the example of these editors. Imitation is the sincerest form of flattery, and the authors of the countless scientific manuals show a sincerity in the admiration for their predecessors that is beautiful to contemplate. The amount of copying from one text-book into another by the writers on mechanics, physics, chemistry, electricity, or astronomy is, indeed, marvellous, and the regularity and precision with which they keep behind the times in stating the facts is also a matter of wonder. But the especial weakness in compositions of this character is the entire absence of references to the original papers from which the extracts are taken.

Ganot's Physics, for instance, is a good treatise; an excellent one. But how much more valuable would the book be to the scientific worker, if the editors had referred the reader to the time and place in which the investigations and experiments they only outline are given full and complete.

We have dwelt upon this matter at some length, because Mr. Cameron's book is a marked exception to the class of books above described. There is hardly a page in it that does not contain, as foot-notes, references to chemical, pharmaceutical or medical journals, to standard works, to lectures, to exhibition reports, or to English, German or United States patents. The book shows the results of wide reading and of careful collection of data, and in the com-

paratively small space of some 300 pages the reader is directed to a thousand sources of information of a most valuable kind. There are many illustrations of apparatus and machinery; tables showing strength of solutions, properties of oils, relation between degrees Baumé and specific gravity, and so on. These last tables are incorrect. In fact, in nearly all English books the densities by Beaumé's hydrometer are incorrect. The reason of this probably is that the English use this hydrometer very little, preferring Twaddle's. It should be borne in mind, also, that the gallons used in the various recipes are English gallons, and therefore of twenty per cent. greater capacity than ours (ten pounds of water as against eight and one-third).

We have not space here to give a detailed analysis of the book, but can recommend it to any one interested in the manufacture of soap or of candles, as a work that will prove most useful to him. H. P., Jr.

HINTS ON HOUSE BUILDING. By Robt. Grimshaw. New York: Practical Publishing Company. 1887.

This is a little manual of notes, compiled by the author during his active experiences, and, as the name indicates, it contains many brief but useful suggestions which will be found to add materially to the comfort and convenience of the home, and which might otherwise be overlooked at a critical moment.

The book is not indexed, but each paragraph is prefaced by its subject matter in small capitals, and as there are but thirty-two pages duodecimo, it is not difficult to find a hint relative to some special feature. It would seem to us, however, to be an improvement, had the subjects been arranged with some approximation to an alphabetical order. L. M. H.

AN INDEX TO ENGINEERING PERIODICALS, 1883–1887. By Francis E. Galloupe, M.E. Boston: Published by the *Engineering News* Publishing Company, New York. 8vo, cloth, 294 pp. $2.

The title of this work is sufficiently explicit. It is only necessary to add the names of the periodicals which have been indexed, during these five years, to give its scope. They are: *Eng. News*, *Iron Age*, *Mechanics*, *Am. Eng.*, *Sanitary Eng.*, *Eng. and Build'g Record*, *Railroad Gazette*, *Van Nostrand's Eng. Mag.*, *R. R. and Eng. Journal*, JOURNAL OF THE FRANKLIN INSTITUTE, *Street R'y Gazette*, *Electrician and El. Eng.*, *Elec. Rev.*, *Elec. World*, *Sci. Am. Supplement*, *The Locomotive*, *Society of Arts Proceedings*, Mass., *Engineering* (London), *The Engineer* (London).

Although comprehensive, the list is by no means complete, yet the author has rendered an invaluable work to the scientific professions and to the arts by thus placing it in the power of those engaged in investigations and research to save much time and trouble for a trifling expense. The subjects are classified and arranged in alphabetical order, making the reference easy. The book is indispensable, and the only regret is that its scope is not greater, still it is a move in the right direction, which should be continued by annual appendices, if possible, to keep it up to date. L. M. H.

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